



**THE DATASHEET OF
LPC1751FBD80,551**





LPC1759/58/56/54/52/51

32-bit ARM Cortex-M3 MCU; up to 512 kB flash and 64 kB SRAM with Ethernet, USB 2.0 Host/Device/OTG, CAN

Rev. 8.7 — 8 September 2020

Product data sheet

1. General description

The LPC1759/58/56/54/52/51 are ARM Cortex-M3 based microcontrollers for embedded applications featuring a high level of integration and low power consumption. The ARM Cortex-M3 is a next generation core that offers system enhancements such as enhanced debug features and a higher level of support block integration.

The LPC1758/56/57/54/52/51 operate at CPU frequencies of up to 100 MHz. The LPC1759 operates at CPU frequencies of up to 120 MHz. The ARM Cortex-M3 CPU incorporates a 3-stage pipeline and uses a Harvard architecture with separate local instruction and data buses as well as a third bus for peripherals. The ARM Cortex-M3 CPU also includes an internal prefetch unit that supports speculative branching.

The peripheral complement of the LPC1759/58/56/54/52/51 includes up to 512 kB of flash memory, up to 64 kB of data memory, Ethernet MAC, USB Device/Host/OTG interface, 8-channel general purpose DMA controller, 4 UARTs, 2 CAN channels, 2 SSP controllers, SPI interface, 2 I²C-bus interfaces, 2-input plus 2-output I²S-bus interface, 6 channel 12-bit ADC, 10-bit DAC, motor control PWM, Quadrature Encoder interface, 4 general purpose timers, 6-output general purpose PWM, ultra-low power Real-Time Clock (RTC) with separate battery supply, and up to 52 general purpose I/O pins.

For additional documentation, see [Section 19 “References”](#).

2. Features and benefits

- ARM Cortex-M3 processor, running at frequencies of up to 100 MHz (LPC1758/56/57/54/52/51) or of up to 120 MHz (LPC1759). A Memory Protection Unit (MPU) supporting eight regions is included.
- ARM Cortex-M3 built-in Nested Vectored Interrupt Controller (NVIC).
- Up to 512 kB on-chip flash programming memory. Enhanced flash memory accelerator enables high-speed 120 MHz operation with zero wait states.
- In-System Programming (ISP) and In-Application Programming (IAP) via on-chip bootloader software.
- On-chip SRAM includes:
 - ◆ Up to 32 kB of SRAM on the CPU with local code/data bus for high-performance CPU access.
 - ◆ Two/one 16 kB SRAM blocks with separate access paths for higher throughput. These SRAM blocks may be used for Ethernet (LPC1758 only), USB, and DMA memory, as well as for general purpose CPU instruction and data storage.



- Eight channel General Purpose DMA controller (GPDMA) on the AHB multilayer matrix that can be used with the SSP, I²S-bus, UART, the Analog-to-Digital and Digital-to-Analog converter peripherals, timer match signals, and for memory-to-memory transfers.
- Multilayer AHB matrix interconnect provides a separate bus for each AHB master. AHB masters include the CPU, General Purpose DMA controller, Ethernet MAC (LPC1758 only), and the USB interface. This interconnect provides communication with no arbitration delays.
- Split APB bus allows high throughput with few stalls between the CPU and DMA.
- Serial interfaces:
 - ◆ On the LPC1758 only, Ethernet MAC with RMII interface and dedicated DMA controller.
 - ◆ USB 2.0 full-speed device/Host/OTG controller with dedicated DMA controller and on-chip PHY for device, Host, and OTG functions. The LPC1752/51 include a USB device controller only.
 - ◆ Four UARTs with fractional baud rate generation, internal FIFO, and DMA support. One UART has modem control I/O and RS-485/EIA-485 support, and one UART has IrDA support.
 - ◆ CAN 2.0B controller with two (LPC1759/58/56) or one (LPC1754/52/51) channels.
 - ◆ SPI controller with synchronous, serial, full duplex communication and programmable data length.
 - ◆ Two SSP controllers with FIFO and multi-protocol capabilities. The SSP interfaces can be used with the GPDMA controller.
 - ◆ Two I²C-bus interfaces supporting fast mode with a data rate of 400 kbit/s with multiple address recognition and monitor mode.
 - ◆ On the LPC1759/58/56 only, I²S (Inter-IC Sound) interface for digital audio input or output, with fractional rate control. The I²S-bus interface can be used with the GPDMA. The I²S-bus interface supports 3-wire and 4-wire data transmit and receive as well as master clock input/output.
- Other peripherals:
 - ◆ 52 General Purpose I/O (GPIO) pins with configurable pull-up/down resistors. All GPIOs support a new, configurable open-drain operating mode. The GPIO block is accessed through the AHB multilayer bus for fast access and located in memory such that it supports Cortex-M3 bit banding and use by the General Purpose DMA Controller.
 - ◆ 12-bit Analog-to-Digital Converter (ADC) with input multiplexing among six pins, conversion rates up to 200 kHz, and multiple result registers. The 12-bit ADC can be used with the GPDMA controller.
 - ◆ On the LPC1759/58/56/54 only, 10-bit Digital-to-Analog Converter (DAC) with dedicated conversion timer and DMA support.
 - ◆ Four general purpose timers/counters, with a total of three capture inputs and ten compare outputs. Each timer block has an external count input. Specific timer events can be selected to generate DMA requests.
 - ◆ One motor control PWM with support for three-phase motor control.
 - ◆ Quadrature encoder interface that can monitor one external quadrature encoder.
 - ◆ One standard PWM/timer block with external count input.
 - ◆ Real-Time Clock (RTC) with a separate power domain and dedicated RTC oscillator. The RTC block includes 20 bytes of battery-powered backup registers.

- ◆ WatchDog Timer (WDT). The WDT can be clocked from the internal RC oscillator, the RTC oscillator, or the APB clock.
- ◆ ARM Cortex-M3 system tick timer, including an external clock input option.
- ◆ Repetitive Interrupt Timer (RIT) provides programmable and repeating timed interrupts.
- ◆ Each peripheral has its own clock divider for further power savings.
- Standard JTAG debug interface for compatibility with existing tools. Serial Wire Debug and Serial Wire Trace Port options. Boundary scan Description Language (BSDL) is not available for this device.
- Emulation trace module enables non-intrusive, high-speed real-time tracing of instruction execution.
- Integrated PMU (Power Management Unit) automatically adjusts internal regulators to minimize power consumption during Sleep, Deep sleep, Power-down, and Deep power-down modes.
- Four reduced power modes: Sleep, Deep-sleep, Power-down, and Deep power-down.
- Single 3.3 V power supply (2.4 V to 3.6 V).
- One external interrupt input configurable as edge/level sensitive. All pins on Port 0 and Port 2 can be used as edge sensitive interrupt sources.
- Non-maskable Interrupt (NMI) input.
- The Wakeup Interrupt Controller (WIC) allows the CPU to automatically wake up from any priority interrupt that can occur while the clocks are stopped in Deep sleep, Power-down, and Deep power-down modes.
- Processor wake-up from Power-down mode via any interrupt able to operate during Power-down mode (includes external interrupts, RTC interrupt, USB activity, Ethernet wake-up interrupt (LPC1758 only), CAN bus activity, Port 0/2 pin interrupt, and NMI).
- Brownout detect with separate threshold for interrupt and forced reset.
- Power-On Reset (POR).
- Crystal oscillator with an operating range of 1 MHz to 25 MHz.
- 4 MHz internal RC oscillator trimmed to 1 % accuracy that can optionally be used as a system clock.
- PLL allows CPU operation up to the maximum CPU rate without the need for a high-frequency crystal. May be run from the main oscillator, the internal RC oscillator, or the RTC oscillator.
- USB PLL for added flexibility.
- Code Read Protection (CRP) with different security levels.
- Unique device serial number for identification purposes.
- Available as 80-pin LQFP package (12 mm × 12 mm × 1.4 mm).

3. Applications

- eMetering
- Lighting
- Industrial networking
- Alarm systems
- White goods
- Motor control

4. Ordering information

Table 1. Ordering information

| Type number | Package | | |
|--------------|---------|---|----------|
| | Name | Description | Version |
| LPC1759FBD80 | LQFP80 | plastic low-profile quad package; 80 leads; body 12 × 12 × 1.4 mm | SOT315-1 |
| LPC1758FBD80 | LQFP80 | plastic low-profile quad package; 80 leads; body 12 × 12 × 1.4 mm | SOT315-1 |
| LPC1756FBD80 | LQFP80 | plastic low-profile quad package; 80 leads; body 12 × 12 × 1.4 mm | SOT315-1 |
| LPC1754FBD80 | LQFP80 | plastic low-profile quad package; 80 leads; body 12 × 12 × 1.4 mm | SOT315-1 |
| LPC1752FBD80 | LQFP80 | plastic low-profile quad package; 80 leads; body 12 × 12 × 1.4 mm | SOT315-1 |
| LPC1751FBD80 | LQFP80 | plastic low-profile quad package; 80 leads; body 12 × 12 × 1.4 mm | SOT315-1 |

4.1 Ordering options

Table 2. Ordering options

| Type number | Device order part number | Flash (kB) | SRAM in kB | | | | Ethernet | USB | CAN | I ² S-bus | DAC | GPIO | Maximum CPU operating frequency (MHz) |
|--------------|--------------------------|------------|------------|-----------|-----------|-------|----------|-----------------|-----|----------------------|-----|------|---------------------------------------|
| | | | CPU | AHB SRAM0 | AHB SRAM1 | Total | | | | | | | |
| LPC1759FBD80 | LPC1759FBD80,551 | 512 | 32 | 16 | 16 | 64 | no | Device/Host/OTG | 2 | yes | yes | 52 | 120 |
| LPC1758FBD80 | LPC1758FBD80Y | 512 | 32 | 16 | 16 | 64 | yes | Device/Host/OTG | 2 | yes | yes | 52 | 100 |
| LPC1756FBD80 | LPC1756FBD80/CP327 | 256 | 16 | 16 | - | 32 | no | Device/Host/OTG | 2 | yes | yes | 52 | 100 |
| LPC1754FBD80 | LPC1754FBD80,551 | 128 | 16 | 16 | - | 32 | no | Device/Host/OTG | 1 | no | yes | 52 | 100 |
| LPC1752FBD80 | LPC1752FBD80,551 | 64 | 16 | - | - | 16 | no | Device only | 1 | no | no | 52 | 100 |
| LPC1751FBD80 | LPC1751FBD80,551 | 32 | 8 | - | - | 8 | no | Device only | 1 | no | no | 52 | 100 |

5. Marking

The LPC175x devices typically have the following top-side marking:

LPC175xxxx

xxxxxxx

xxYYWWR[x]

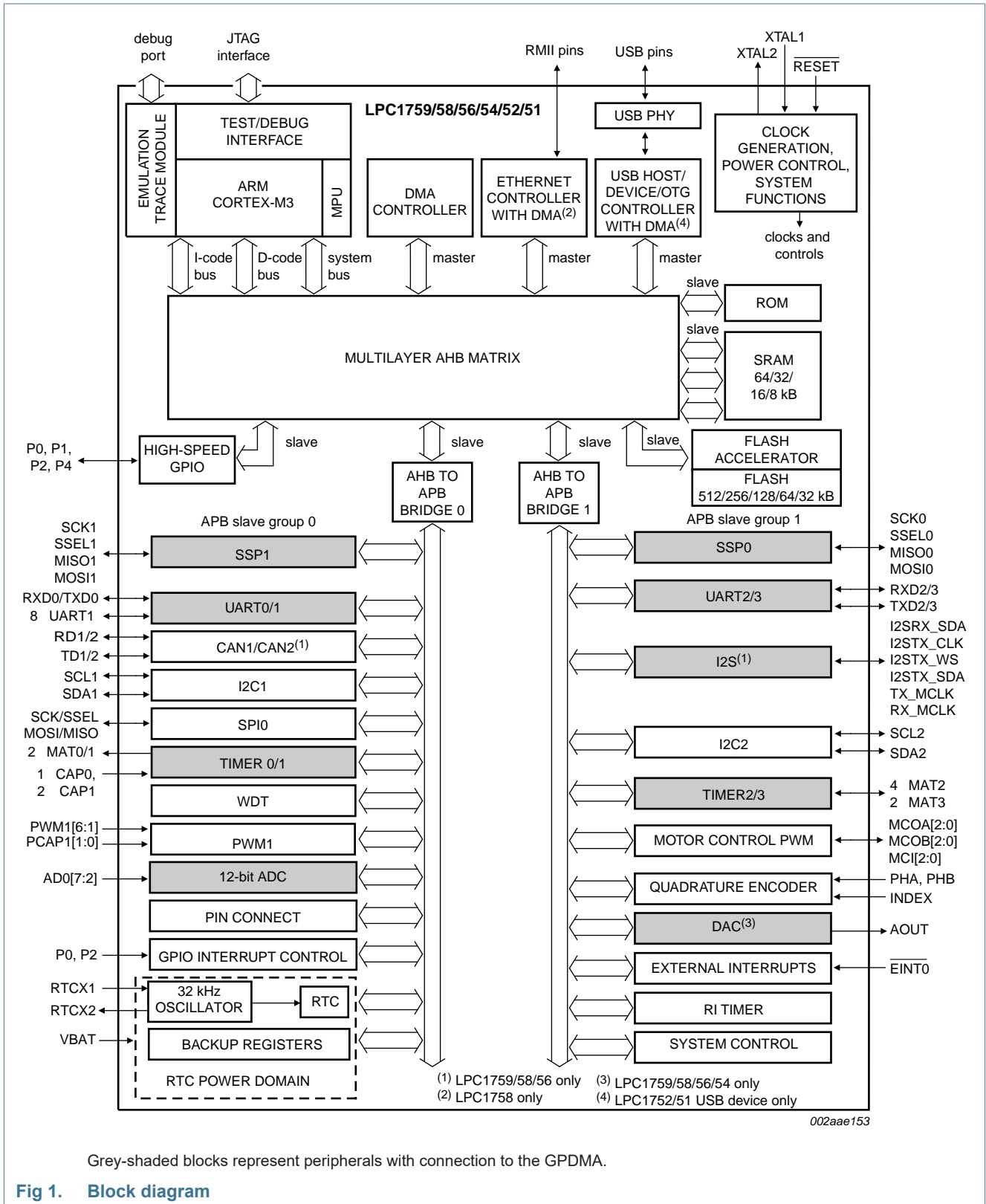
The last/second to last letter in the third line (field 'R') will identify the device revision. This data sheet covers the following revisions of the LPC175x:

Table 3. Device revision table

| Revision identifier (R) | Revision description |
|-------------------------|-------------------------|
| '.' | Initial device revision |
| 'A' | Second device revision |
| 'C' | Third device revision |

Field 'YY' states the year the device was manufactured. Field 'WW' states the week the device was manufactured during that year.

6. Block diagram



7. Pinning information

7.1 Pinning

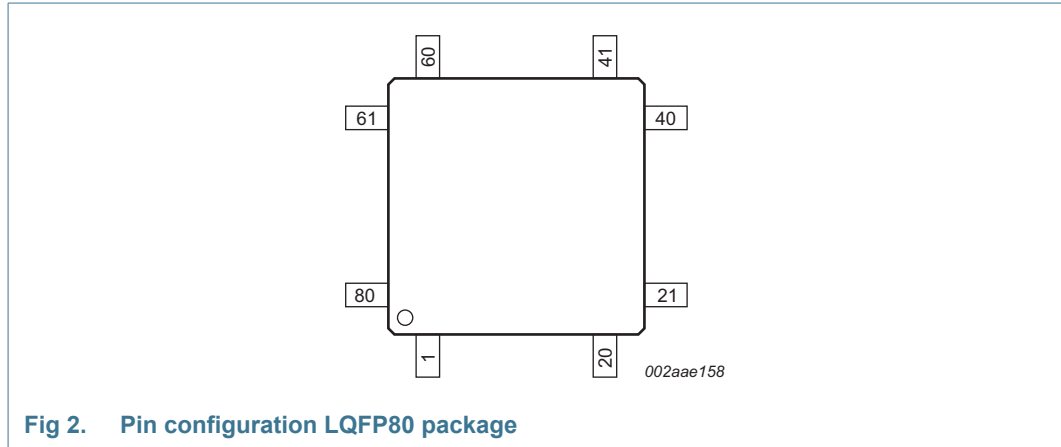


Fig 2. Pin configuration LQFP80 package

7.2 Pin description

Table 4. Pin description

| Symbol | Pin | Type | Description |
|-------------------------------|-------------------|------|--|
| P0[0] to P0[31] | | I/O | Port 0: Port 0 is a 32-bit I/O port with individual direction controls for each bit. The operation of Port 0 pins depends upon the pin function selected via the pin connect block. Some port pins are not available on the LQFP80 package. |
| P0[0]/RD1/TXD3/SDA1 | 37 ^[1] | I/O | P0[0] — General purpose digital input/output pin. |
| | | I | RD1 — CAN1 receiver input. |
| | | O | TXD3 — Transmitter output for UART3. |
| | | I/O | SDA1 — I ² C1 data input/output (this is not an I ² C-bus compliant open-drain pin). |
| P0[1]/TD1/RXD3/SCL1 | 38 ^[1] | I/O | P0[1] — General purpose digital input/output pin. |
| | | O | TD1 — CAN1 transmitter output. |
| | | I | RXD3 — Receiver input for UART3. |
| | | I/O | SCL1 — I ² C1 clock input/output (this is not an I ² C-bus compliant open-drain pin). |
| P0[2]/TXD0/AD0[7] | 79 ^[2] | I/O | P0[2] — General purpose digital input/output pin. |
| | | O | TXD0 — Transmitter output for UART0. |
| | | I | AD0[7] — A/D converter 0, input 7. |
| P0[3]/RXD0/AD0[6] | 80 ^[2] | I/O | P0[3] — General purpose digital input/output pin. |
| | | I | RXD0 — Receiver input for UART0. |
| | | I | AD0[6] — A/D converter 0, input 6. |
| P0[6]/I2SRX_SDA/SSEL1/MAT2[0] | 64 ^[1] | I/O | P0[6] — General purpose digital input/output pin. |
| | | I/O | I2SRX_SDA — Receive data. It is driven by the transmitter and read by the receiver. Corresponds to the signal SD in the <i>I²S-bus specification</i> . (LPC1759/58/56 only). |
| | | I/O | SSEL1 — Slave Select for SSP1. |
| | | O | MAT2[0] — Match output for Timer 2, channel 0. |

Table 4. Pin description ...continued

| Symbol | Pin | Type | Description |
|-----------------------------------|-------------------|------|---|
| P0[7]/I2STX_CLK/ SCK1/MAT2[1] | 63 ^[1] | I/O | P0[7] — General purpose digital input/output pin. |
| | | I/O | I2STX_CLK — Transmit Clock. It is driven by the master and received by the slave. Corresponds to the signal SCK in the <i>I²S-bus specification</i> . (LPC1759/58/56 only). |
| | | I/O | SCK1 — Serial Clock for SSP1. |
| | | O | MAT2[1] — Match output for Timer 2, channel 1. |
| P0[8]/I2STX_WS/ MISO1/MAT2[2] | 62 ^[1] | I/O | P0[8] — General purpose digital input/output pin. |
| | | I/O | I2STX_WS — Transmit Word Select. It is driven by the master and received by the slave. Corresponds to the signal WS in the <i>I²S-bus specification</i> . (LPC1759/58/56 only). |
| | | I/O | MISO1 — Master In Slave Out for SSP1. |
| | | O | MAT2[2] — Match output for Timer 2, channel 2. |
| P0[9]/I2STX_SDA/ MOSI1/MAT2[3] | 61 ^[1] | I/O | P0[9] — General purpose digital input/output pin. |
| | | I/O | I2STX_SDA — Transmit data. It is driven by the transmitter and read by the receiver. Corresponds to the signal SD in the <i>I²S-bus specification</i> . (LPC1759/58/56 only). |
| | | I/O | MOSI1 — Master Out Slave In for SSP1. |
| | | O | MAT2[3] — Match output for Timer 2, channel 3. |
| P0[10]/TXD2/ SDA2/MAT3[0] | 39 ^[1] | I/O | P0[10] — General purpose digital input/output pin. |
| | | O | TXD2 — Transmitter output for UART2. |
| | | I/O | SDA2 — I ² C2 data input/output (this is not an open-drain pin). |
| | | O | MAT3[0] — Match output for Timer 3, channel 0. |
| P0[11]/RXD2/ SCL2/MAT3[1] | 40 ^[1] | I/O | P0[11] — General purpose digital input/output pin. |
| | | I | RXD2 — Receiver input for UART2. |
| | | I/O | SCL2 — I ² C2 clock input/output (this is not an open-drain pin). |
| | | O | MAT3[1] — Match output for Timer 3, channel 1. |
| P0[15]/TXD1/ SCK0/SCK | 47 ^[1] | I/O | P0[15] — General purpose digital input/output pin. |
| | | O | TXD1 — Transmitter output for UART1. |
| | | I/O | SCK0 — Serial clock for SSP0. |
| | | I/O | SCK — Serial clock for SPI. |
| P0[16]/RXD1/ SSEL0/SSEL | 48 ^[1] | I/O | P0[16] — General purpose digital input/output pin. |
| | | I | RXD1 — Receiver input for UART1. |
| | | I/O | SSEL0 — Slave Select for SSP0. |
| | | I/O | SSEL — Slave Select for SPI. |
| P0[17]/CTS1/ MISO0/MISO | 46 ^[1] | I/O | P0[17] — General purpose digital input/output pin. |
| | | I | CTS1 — Clear to Send input for UART1. |
| | | I/O | MISO0 — Master In Slave Out for SSP0. |
| | | I/O | MISO — Master In Slave Out for SPI. |
| P0[18]/DCD1/ MOSI0/MOSI | 45 ^[1] | I/O | P0[18] — General purpose digital input/output pin. |
| | | I | DCD1 — Data Carrier Detect input for UART1. |
| | | I/O | MOSI0 — Master Out Slave In for SSP0. |
| | | I/O | MOSI — Master Out Slave In for SPI. |

Table 4. Pin description ...continued

| Symbol | Pin | Type | Description |
|------------------------------|-------------------|------|--|
| P0[22]/RTS1/TD1 | 44 ^[1] | I/O | P0[22] — General purpose digital input/output pin. |
| | | O | RTS1 — Request to Send output for UART1. Can also be configured to be an RS-485/EIA-485 output enable signal. |
| | | O | TD1 — CAN1 transmitter output. |
| P0[25]/AD0[2]/I2SRX_SDA/TXD3 | 72 ^[2] | I/O | P0[25] — General purpose digital input/output pin. |
| | | I | AD0[2] — A/D converter 0, input 2. |
| | | I/O | I2SRX_SDA — Receive data. It is driven by the transmitter and read by the receiver. Corresponds to the signal SD in the <i>I²S-bus specification</i> . (LPC1759/58/56 only). |
| | | O | TXD3 — Transmitter output for UART3. |
| P0[26]/AD0[3]/AOUT/RXD3 | 63 ^[3] | I/O | P0[26] — General purpose digital input/output pin. |
| | | I | AD0[3] — A/D converter 0, input 3. |
| | | O | AOUT — DAC output. (LPC1759/58/56/54 only). |
| | | I | RXD3 — Receiver input for UART3. |
| P0[29]/USB_D+ | 22 ^[4] | I/O | P0[29] — General purpose digital input/output pin. |
| | | I/O | USB_D+ — USB bidirectional D+ line. |
| P0[30]/USB_D- | 23 ^[4] | I/O | P0[30] — General purpose digital input/output pin. |
| | | I/O | USB_D- — USB bidirectional D- line. |
| P1[0] to P1[31] | | I/O | Port 1: Port 1 is a 32-bit I/O port with individual direction controls for each bit. The operation of port 1 pins depends upon the pin function selected via the pin connect block. Some port pins are not available on the LQFP80 package. |
| P1[0]/ENET_TXD0 | 76 ^[1] | I/O | P1[0] — General purpose digital input/output pin. |
| | | O | ENET_TXD0 — Ethernet transmit data 0. (LPC1758 only). |
| P1[1]/ENET_TXD1 | 75 ^[1] | I/O | P1[1] — General purpose digital input/output pin. |
| | | O | ENET_TXD1 — Ethernet transmit data 1. (LPC1758 only). |
| P1[4]/ENET_TX_EN | 74 ^[1] | I/O | P1[4] — General purpose digital input/output pin. |
| | | O | ENET_TX_EN — Ethernet transmit data enable. (LPC1758 only). |
| P1[8]/ENET_CRS | 73 ^[1] | I/O | P1[8] — General purpose digital input/output pin. |
| | | I | ENET_CRS — Ethernet carrier sense. (LPC1758 only). |
| P1[9]/ENET_RXD0 | 72 ^[1] | I/O | P1[9] — General purpose digital input/output pin. |
| | | I | ENET_RXD0 — Ethernet receive data. (LPC1758 only). |
| P1[10]/ENET_RXD1 | 71 ^[1] | I/O | P1[10] — General purpose digital input/output pin. |
| | | I | ENET_RXD1 — Ethernet receive data. (LPC1758 only). |
| P1[14]/ENET_RX_ER | 70 ^[1] | I/O | P1[14] — General purpose digital input/output pin. |
| | | I | ENET_RX_ER — Ethernet receive error. (LPC1758 only). |
| P1[15]/ENET_REF_CLK | 69 ^[1] | I/O | P1[15] — General purpose digital input/output pin. |
| | | I | ENET_REF_CLK — Ethernet reference clock. (LPC1758 only). |

Table 4. Pin description ...continued

| Symbol | Pin | Type | Description |
|---|-------------------|------|--|
| P1[18]/ USB_UP_LED/ PWM1[1]/ CAP1[0] | 25 ^[1] | I/O | P1[18] — General purpose digital input/output pin. |
| | | O | USB_UP_LED — USB GoodLink LED indicator. It is LOW when the device is configured (non-control endpoints enabled), or when the host is enabled and has detected a device on the bus. It is HIGH when the device is not configured, or when host is enabled and has not detected a device on the bus, or during global suspend. It transitions between LOW and HIGH (flashes) when the host is enabled and detects activity on the bus. |
| | | O | PWM1[1] — Pulse Width Modulator 1, channel 1 output. |
| | | I | CAP1[0] — Capture input for Timer 1, channel 0. |
| P1[19]/MCOA0/ USB_PPWR CAP1[1] | 26 ^[1] | I/O | P1[19] — General purpose digital input/output pin. |
| | | O | MCOA0 — Motor control PWM channel 0, output A. |
| | | O | USB_PPWR — Port Power enable signal for USB port. (LPC1759/58/56/54 only). |
| | | I | CAP1[1] — Capture input for Timer 1, channel 1. |
| P1[20]/MCI0/ PWM1[2]/SCK0 | 27 ^[1] | I/O | P1[20] — General purpose digital input/output pin. |
| | | I | MCI0 — Motor control PWM channel 0, input. Also Quadrature Encoder Interface PHA input. |
| | | O | PWM1[2] — Pulse Width Modulator 1, channel 2 output. |
| | | I/O | SCK0 — Serial clock for SSP0. |
| P1[22]/MCOB0/ USB_PWRD/ MAT1[0] | 28 ^[1] | I/O | P1[22] — General purpose digital input/output pin. |
| | | O | MCOB0 — Motor control PWM channel 0, output B. |
| | | I | USB_PWRD — Power Status for USB port (host power switch). (LPC1759/58/56/54 only). |
| | | O | MAT1[0] — Match output for Timer 1, channel 0. |
| P1[23]/MCI1/ PWM1[4]/MISO0 | 29 ^[1] | I/O | P1[23] — General purpose digital input/output pin. |
| | | I | MCI1 — Motor control PWM channel 1, input. Also Quadrature Encoder Interface PHB input. |
| | | O | PWM1[4] — Pulse Width Modulator 1, channel 4 output. |
| | | I/O | MISO0 — Master In Slave Out for SSP0. |
| P1[24]/MCI2/ PWM1[5]/MOSI0 | 30 ^[1] | I/O | P1[24] — General purpose digital input/output pin. |
| | | I | MCI2 — Motor control PWM channel 2, input. Also Quadrature Encoder Interface INDEX input. |
| | | O | PWM1[5] — Pulse Width Modulator 1, channel 5 output. |
| | | I/O | MOSI0 — Master Out Slave in for SSP0. |
| P1[25]/MCOA1/ MAT1[1] | 31 ^[1] | I/O | P1[25] — General purpose digital input/output pin. |
| | | O | MCOA1 — Motor control PWM channel 1, output A. |
| | | O | MAT1[1] — Match output for Timer 1, channel 1. |
| P1[26]/MCOB1/ PWM1[6]/CAP0[0] | 32 ^[1] | I/O | P1[26] — General purpose digital input/output pin. |
| | | O | MCOB1 — Motor control PWM channel 1, output B. |
| | | O | PWM1[6] — Pulse Width Modulator 1, channel 6 output. |
| | | I | CAP0[0] — Capture input for Timer 0, channel 0. |

Table 4. Pin description ...continued

| Symbol | Pin | Type | Description |
|---|-------------------|------|--|
| P1[28]/MCOA2/ PCAP1[0]/ MAT0[0] | 35 ^[1] | I/O | P1[28] — General purpose digital input/output pin. |
| | | O | MCOA2 — Motor control PWM channel 2, output A. |
| | | I | PCAP1[0] — Capture input for PWM1, channel 0. |
| | | O | MAT0[0] — Match output for Timer 0, channel 0. |
| P1[29]/MCOB2/ PCAP1[1]/ MAT0[1] | 36 ^[1] | I/O | P1[29] — General purpose digital input/output pin. |
| | | O | MCOB2 — Motor control PWM channel 2, output B. |
| | | I | PCAP1[1] — Capture input for PWM1, channel 1. |
| | | O | MAT0[1] — Match output for Timer 0, channel 1. |
| P1[30]/V _{BUS} / AD0[4] | 18 ^[2] | I/O | P1[30] — General purpose digital input/output pin. |
| | | I | V_{BUS} — Monitors the presence of USB bus power. Note: This signal must be HIGH for USB reset to occur. |
| | | I | AD0[4] — A/D converter 0, input 4. |
| P1[31]/SCK1/ AD0[5] | 17 ^[2] | I/O | P1[31] — General purpose digital input/output pin. |
| | | I/O | SCK1 — Serial Clock for SSP1. |
| | | I | AD0[5] — A/D converter 0, input 5. |
| P2[0] to P2[31] | | I/O | Port 2: Port 2 is a 32-bit I/O port with individual direction controls for each bit. The operation of port 2 pins depends upon the pin function selected via the pin connect block. Some port pins are not available on the LQFP80 package. |
| P2[0]/PWM1[1]/ TXD1 | 60 ^[1] | I/O | P2[0] — General purpose digital input/output pin. |
| | | O | PWM1[1] — Pulse Width Modulator 1, channel 1 output. |
| | | O | TXD1 — Transmitter output for UART1. |
| P2[1]/PWM1[2]/ RXD1 | 59 ^[1] | I/O | P2[1] — General purpose digital input/output pin. |
| | | O | PWM1[2] — Pulse Width Modulator 1, channel 2 output. |
| | | I | RXD1 — Receiver input for UART1. |
| P2[2]/PWM1[3]/ CTS1/ TRACEDATA[3] | 58 ^[1] | I/O | P2[2] — General purpose digital input/output pin. |
| | | O | PWM1[3] — Pulse Width Modulator 1, channel 3 output. |
| | | I | CTS1 — Clear to Send input for UART1. |
| | | O | TRACEDATA[3] — Trace data, bit 3. |
| P2[3]/PWM1[4]/ DCD1/ TRACEDATA[2] | 55 ^[1] | I/O | P2[3] — General purpose digital input/output pin. |
| | | O | PWM1[4] — Pulse Width Modulator 1, channel 4 output. |
| | | I | DCD1 — Data Carrier Detect input for UART1. |
| | | O | TRACEDATA[2] — Trace data, bit 2. |
| P2[4]/PWM1[5]/ DSR1/ TRACEDATA[1] | 54 ^[1] | I/O | P2[4] — General purpose digital input/output pin. |
| | | O | PWM1[5] — Pulse Width Modulator 1, channel 5 output. |
| | | I | DSR1 — Data Set Ready input for UART1. |
| | | O | TRACEDATA[1] — Trace data, bit 1. |
| P2[5]/PWM1[6]/ DTR1/ TRACEDATA[0] | 53 ^[1] | I/O | P2[5] — General purpose digital input/output pin. |
| | | O | PWM1[6] — Pulse Width Modulator 1, channel 6 output. |
| | | O | DTR1 — Data Terminal Ready output for UART1. Can also be configured to be an RS-485/EIA-485 output enable signal. |
| | | O | TRACEDATA[0] — Trace data, bit 0. |

Table 4. Pin description ...continued

| Symbol | Pin | Type | Description |
|---------------------------------|-------------------|------|--|
| P2[6]/PCAP1[0]/ RI1/TRACECLK | 52 ^[1] | I/O | P2[6] — General purpose digital input/output pin. |
| | | I | PCAP1[0] — Capture input for PWM1, channel 0. |
| | | I | RI1 — Ring Indicator input for UART1. |
| | | O | TRACECLK — Trace Clock. |
| P2[7]/RD2/ RTS1 | 51 ^[1] | I/O | P2[7] — General purpose digital input/output pin. |
| | | I | RD2 — CAN2 receiver input. (LPC1759/58/56 only). |
| | | O | RTS1 — Request to Send output for UART1. Can also be configured to be an RS-485/EIA-485 output enable signal. |
| P2[8]/TD2/ TXD2 | 50 ^[1] | I/O | P2[8] — General purpose digital input/output pin. |
| | | O | TD2 — CAN2 transmitter output. (LPC1759/58/56 only). |
| | | O | TXD2 — Transmitter output for UART2. |
| P2[9]/ USB_CONNECT/ RXD2 | 49 ^[1] | I/O | P2[9] — General purpose digital input/output pin. |
| | | O | USB_CONNECT — Signal used to switch an external 1.5 kΩ resistor under software control. Used with the SoftConnect USB feature. |
| | | I | RXD2 — Receiver input for UART2. |
| P2[10]/EINT0/NMI | 41 ^[5] | I/O | P2[10] — General purpose digital input/output pin. A LOW level on this pin during reset starts the ISP command handler. |
| | | I | EINT0 — External interrupt 0 input. |
| | | I | NMI — Non-maskable interrupt input. |
| P4[0] to P4[31] | | I/O | Port 4: Port 4 is a 32-bit I/O port with individual direction controls for each bit. The operation of port 4 pins depends upon the pin function selected via the pin connect block. Some port pins are not available on the LQFP80 package. |
| P4[28]/RX_MCLK/ MAT2[0]/TXD3 | 65 ^[1] | I/O | P4[28] — General purpose digital input/output pin. |
| | | O | RX_MCLK — I ² S receive master clock. (LPC1759/58/56 only). |
| | | O | MAT2[0] — Match output for Timer 2, channel 0. |
| | | O | TXD3 — Transmitter output for UART3. |
| P4[29]/TX_MCLK/ MAT2[1]/RXD3 | 68 ^[1] | I/O | P4[29] — General purpose digital input/output pin. |
| | | O | TX_MCLK — I ² S transmit master clock. (LPC1759/58/56 only). |
| | | O | MAT2[1] — Match output for Timer 2, channel 1. |
| | | I | RXD3 — Receiver input for UART3. |
| TDO/SWO | 1 ^[6] | O | TDO — Test Data out for JTAG interface. |
| | | O | SWO — Serial wire trace output. |
| TDI | 2 ^[7] | I | TDI — Test Data in for JTAG interface. |
| TMS/SWDIO | 3 ^[7] | I | TMS — Test Mode Select for JTAG interface. |
| | | I/O | SWDIO — Serial wire debug data input/output. |
| $\overline{\text{TRST}}$ | 4 ^[7] | I | $\overline{\text{TRST}}$ — Test Reset for JTAG interface. |
| TCK/SWDCLK | 5 ^[6] | I | TCK — Test Clock for JTAG interface. |
| | | I | SWDCLK — Serial wire clock. |
| $\overline{\text{RSTOUT}}$ | 11 | O | $\overline{\text{RSTOUT}}$ — This is a 3.3 V pin. LOW on this pin indicates LPC1759/58/56/54/52/51 being in Reset state. |
| $\overline{\text{RESET}}$ | 14 ^[8] | I | External reset input: A LOW-going pulse as short as 50 ns on this pin resets the device, causing I/O ports and peripherals to take on their default states, and processor execution to begin at address 0. TTL with hysteresis, 5 V tolerant. |

Table 4. Pin description ...continued

| Symbol | Pin | Type | Description |
|---------------------------|------------------------------|------|--|
| XTAL1 | 19 ^{[9][10]} | I | Input to the oscillator circuit and internal clock generator circuits. |
| XTAL2 | 20 ^{[9][10]} | O | Output from the oscillator amplifier. |
| RTCX1 | 13 ^{[9][11]} | I | Input to the RTC oscillator circuit. |
| RTCX2 | 15 ^[9] | O | Output from the RTC oscillator circuit. |
| V _{SS} | 24, 33, 43, 57, 66, 78 | I | ground: 0 V reference. |
| V _{SSA} | 9 | I | analog ground: 0 V reference. This should nominally be the same voltage as V _{SS} , but should be isolated to minimize noise and error. |
| V _{DD(3V3)} | 21, 42, 56, 77 | I | 3.3 V supply voltage: This is the power supply voltage for the I/O ports. |
| V _{DD(REG)(3V3)} | 34, 67 | I | 3.3 V voltage regulator supply voltage: This is the supply voltage for the on-chip voltage regulator only. |
| V _{DDA} | 8 | I | analog 3.3 V pad supply voltage: This should be nominally the same voltage as V _{DD(3V3)} but should be isolated to minimize noise and error. This voltage is used to power the ADC and DAC. This pin should be tied to 3.3 V if the ADC and DAC are not used. |
| VREFP | 10 | I | ADC positive reference voltage: This should be nominally the same voltage as V _{DDA} but should be isolated to minimize noise and error. Level on this pin is used as a reference for ADC and DAC. This pin should be tied to 3.3 V if the ADC and DAC are not used. |
| VREFN | 12 | I | ADC negative reference voltage: This should be nominally the same voltage as V _{SS} but should be isolated to minimize noise and error. Level on this pin is used as a reference for ADC and DAC. |
| VBAT | 16 ^[11] | I | RTC pin power supply: 3.3 V on this pin supplies the power to the RTC peripheral. |

- [1] 5 V tolerant pad providing digital I/O functions with TTL levels and hysteresis. This pin is pulled up to a voltage level of 2.3 V to 2.6 V.
- [2] 5 V tolerant pad providing digital I/O functions (with TTL levels and hysteresis) and analog input. When configured as a ADC input, digital section of the pad is disabled and the pin is not 5 V tolerant. This pin is pulled up to a voltage level of 2.3 V to 2.6 V.
- [3] 5 V tolerant pad providing digital I/O with TTL levels and hysteresis and analog output function. When configured as the DAC output, digital section of the pad is disabled. This pin is pulled up to a voltage level of 2.3 V to 2.6 V.
- [4] Pad provides digital I/O and USB functions. It is designed in accordance with the *USB specification, revision 2.0* (Full-speed and Low-speed mode only). This pad is not 5 V tolerant.
- [5] 5 V tolerant pad with 10 ns glitch filter providing digital I/O functions with TTL levels and hysteresis. This pin is pulled up to a voltage level of 2.3 V to 2.6 V.
- [6] 5 V tolerant pad with TTL levels and hysteresis. Internal pull-up and pull-down resistors disabled.
- [7] 5 V tolerant pad with TTL levels and hysteresis and internal pull-up resistor.
- [8] 5 V tolerant pad with 20 ns glitch filter providing digital I/O function with TTL levels and hysteresis.
- [9] Pad provides special analog functionality. 32 kHz crystal oscillator must be used with the RTC.
- [10] When the system oscillator is not used, connect XTAL1 and XTAL2 as follows: XTAL1 can be left floating or can be grounded (grounding is preferred to reduce susceptibility to noise). XTAL2 should be left floating.
- [11] When the RTC is not used, connect VBAT to V_{DD(REG)(3V3)} and leave RTCX1 floating.

8. Functional description

8.1 Architectural overview

The ARM Cortex-M3 includes three AHB-Lite buses: the system bus, the I-code bus, and the D-code bus (see [Figure 1](#)). The I-code and D-code core buses are faster than the system bus and are used similarly to Tightly Coupled Memory (TCM) interfaces: one bus dedicated for instruction fetch (I-code) and one bus for data access (D-code). The use of two core buses allows for simultaneous operations if concurrent operations target different devices.

The LPC1759/58/56/54/52/51 use a multi-layer AHB matrix to connect the ARM Cortex-M3 buses and other bus masters to peripherals in a flexible manner that optimizes performance by allowing peripherals that are on different slaves ports of the matrix to be accessed simultaneously by different bus masters.

8.2 ARM Cortex-M3 processor

The ARM Cortex-M3 is a general purpose, 32-bit microprocessor, which offers high performance and very low power consumption. The ARM Cortex-M3 offers many new features, including a Thumb-2 instruction set, low interrupt latency, hardware division, hardware single-cycle multiply, interruptable/continuable multiple load and store instructions, automatic state save and restore for interrupts, tightly integrated interrupt controller with wakeup interrupt controller, and multiple core buses capable of simultaneous accesses.

Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory.

The ARM Cortex-M3 processor is described in detail in the Cortex-M3 Technical Reference Manual that can be found on official ARM website.

8.3 On-chip flash program memory

The LPC1759/58/56/54/52/51 contain up to 512 kB of on-chip flash memory. A new two-port flash accelerator maximizes performance for use with the two fast AHB-Lite buses.

8.4 On-chip SRAM

The LPC1759/58/56/54/52/51 contain a total of up to 64 kB on-chip static RAM memory. This includes the main 32/16/8 kB SRAM, accessible by the CPU and DMA controller on a higher-speed bus, and up to two additional 16 kB each SRAM blocks situated on a separate slave port on the AHB multilayer matrix.

This architecture allows CPU and DMA accesses to be spread over three separate RAMs that can be accessed simultaneously.

8.5 Memory Protection Unit (MPU)

The LPC1759/58/56/54/52/51 have a Memory Protection Unit (MPU) which can be used to improve the reliability of an embedded system by protecting critical data within the user application.

The MPU allows separating processing tasks by disallowing access to each other's data, disabling access to memory regions, allowing memory regions to be defined as read-only and detecting unexpected memory accesses that could potentially break the system.

The MPU separates the memory into distinct regions and implements protection by preventing disallowed accesses. The MPU supports up to 8 regions each of which can be divided into 8 subregions. Accesses to memory locations that are not defined in the MPU regions, or not permitted by the region setting, will cause the Memory Management Fault exception to take place.

8.6 Memory map

The LPC1759/58/56/54/52/51 incorporate several distinct memory regions, shown in the following figures. [Figure 3](#) shows the overall map of the entire address space from the user program viewpoint following reset. The interrupt vector area supports address remapping.

The AHB peripheral area is 2 MB in size, and is divided to allow for up to 128 peripherals. The APB peripheral area is 1 MB in size and is divided to allow for up to 64 peripherals. Each peripheral of either type is allocated 16 kB of space. This allows simplifying the address decoding for each peripheral.

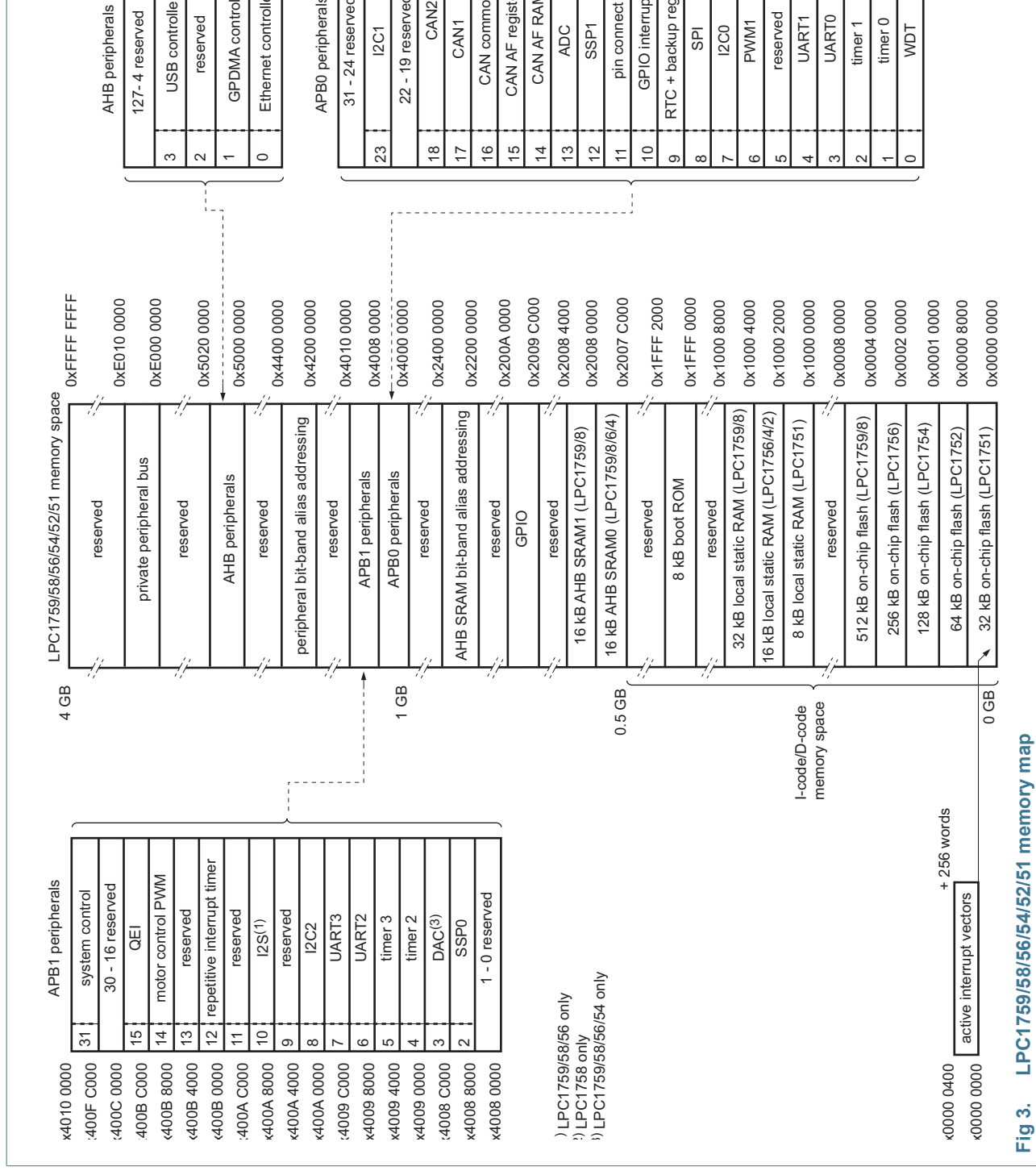


Fig 3. LPC1759/58/56/54/52/51 memory map

8.7 Nested Vectored Interrupt Controller (NVIC)

The NVIC is an integral part of the Cortex-M3. The tight coupling to the CPU allows for low interrupt latency and efficient processing of late arriving interrupts.

8.7.1 Features

- Controls system exceptions and peripheral interrupts
- In the LPC1759/58/56/54/52/51, the NVIC supports 33 vectored interrupts
- 32 programmable interrupt priority levels, with hardware priority level masking
- Relocatable vector table
- Non-Maskable Interrupt (NMI)
- Software interrupt generation

8.7.2 Interrupt sources

Each peripheral device has one interrupt line connected to the NVIC but may have several interrupt flags. Individual interrupt flags may also represent more than one interrupt source.

Any pin on Port 0 and Port 2 (total of 30 pins) regardless of the selected function, can be programmed to generate an interrupt on a rising edge, a falling edge, or both.

8.8 Pin connect block

The pin connect block allows selected pins of the microcontroller to have more than one function. Configuration registers control the multiplexers to allow connection between the pin and the on-chip peripherals.

Peripherals should be connected to the appropriate pins prior to being activated and prior to any related interrupt(s) being enabled. Activity of any enabled peripheral function that is not mapped to a related pin should be considered undefined.

Most pins can also be configured as open-drain outputs or to have a pull-up, pull-down, or no resistor enabled.

8.9 General purpose DMA controller

The GPDMA is an AMBA AHB compliant peripheral allowing selected LPC1759/58/56/54/52/51 peripherals to have DMA support.

The GPDMA enables peripheral-to-memory, memory-to-peripheral, peripheral-to-peripheral, and memory-to-memory transactions. The source and destination areas can each be either a memory region or a peripheral, and can be accessed through the AHB master. The GPDMA controller allows data transfers between the USB and Ethernet (LPC1758 only) controllers and the various on-chip SRAM areas. The supported APB peripherals are SSP0/1, all UARTs, the I²S-bus interface, the ADC, and the DAC. Two match signals for each timer can be used to trigger DMA transfers.

Remark: Note that the DAC is not available on the LPC1752/51, and the I²S-bus interface is not available on the LPC1754/52/51.

8.9.1 Features

- Eight DMA channels. Each channel can support an unidirectional transfer.
- 16 DMA request lines.
- Single DMA and burst DMA request signals. Each peripheral connected to the DMA Controller can assert either a burst DMA request or a single DMA request. The DMA burst size is set by programming the DMA Controller.
- Memory-to-memory, memory-to-peripheral, peripheral-to-memory, and peripheral-to-peripheral transfers are supported.
- Scatter or gather DMA is supported through the use of linked lists. This means that the source and destination areas do not have to occupy contiguous areas of memory.
- Hardware DMA channel priority.
- AHB slave DMA programming interface. The DMA Controller is programmed by writing to the DMA control registers over the AHB slave interface.
- One AHB bus master for transferring data. The interface transfers data when a DMA request goes active.
- 32-bit AHB master bus width.
- Incrementing or non-incrementing addressing for source and destination.
- Programmable DMA burst size. The DMA burst size can be programmed to more efficiently transfer data.
- Internal four-word FIFO per channel.
- Supports 8, 16, and 32-bit wide transactions.
- Big-endian and little-endian support. The DMA Controller defaults to little-endian mode on reset.
- An interrupt to the processor can be generated on a DMA completion or when a DMA error has occurred.
- Raw interrupt status. The DMA error and DMA count raw interrupt status can be read prior to masking.

8.10 Fast general purpose parallel I/O

Device pins that are not connected to a specific peripheral function are controlled by the GPIO registers. Pins may be dynamically configured as inputs or outputs. Separate registers allow setting or clearing any number of outputs simultaneously. The value of the output register may be read back as well as the current state of the port pins.

LPC1759/58/56/54/52/51 use accelerated GPIO functions:

- GPIO registers are accessed through the AHB multilayer bus so that the fastest possible I/O timing can be achieved.
- Mask registers allow treating sets of port bits as a group, leaving other bits unchanged.
- All GPIO registers are byte and half-word addressable.
- Entire port value can be written in one instruction.
- Support for Cortex-M3 bit banding.
- Support for use with the GPDMA controller.

Additionally, any pin on Port 0 and Port 2 (total of 42 pins) providing a digital function can be programmed to generate an interrupt on a rising edge, a falling edge, or both. The edge detection is asynchronous, so it may operate when clocks are not present such as during Power-down mode. Each enabled interrupt can be used to wake up the chip from Power-down mode.

8.10.1 Features

- Bit level set and clear registers allow a single instruction to set or clear any number of bits in one port.
- Direction control of individual bits.
- All I/O default to inputs after reset.
- Pull-up/pull-down resistor configuration and open-drain configuration can be programmed through the pin connect block for each GPIO pin.

8.11 Ethernet (LPC1758 only)

The Ethernet block contains a full featured 10 Mbit/s or 100 Mbit/s Ethernet MAC designed to provide optimized performance through the use of DMA hardware acceleration. Features include a generous suite of control registers, half or full duplex operation, flow control, control frames, hardware acceleration for transmit retry, receive packet filtering and wake-up on LAN activity. Automatic frame transmission and reception with scatter-gather DMA off-loads many operations from the CPU.

The Ethernet block and the CPU share the ARM Cortex-M3 D-code and system bus through the AHB-multilayer matrix to access the various on-chip SRAM blocks for Ethernet data, control, and status information.

The Ethernet block interfaces between an off-chip Ethernet PHY using the Reduced MII (RMII) protocol and the on-chip Media Independent Interface Management (MIIM) serial bus.

The Ethernet block supports bus clock rates of up to 100 MHz.

8.11.1 Features

- Ethernet standards support:
 - Supports 10 Mbit/s or 100 Mbit/s PHY devices including 10 Base-T, 100 Base-TX, 100 Base-FX, and 100 Base-T4.
 - Fully compliant with *IEEE standard 802.3*.
 - Fully compliant with 802.3x full duplex flow control and half duplex back pressure.
 - Flexible transmit and receive frame options.
 - Virtual Local Area Network (VLAN) frame support.
- Memory management:
 - Independent transmit and receive buffers memory mapped to shared SRAM.
 - DMA managers with scatter/gather DMA and arrays of frame descriptors.
 - Memory traffic optimized by buffering and pre-fetching.
- Enhanced Ethernet features:

- Receive filtering.
 - Multicast and broadcast frame support for both transmit and receive.
 - Optional automatic Frame Check Sequence (FCS) insertion with Cyclic Redundancy Check (CRC) for transmit.
 - Selectable automatic transmit frame padding.
 - Over-length frame support for both transmit and receive allows any length frames.
 - Promiscuous receive mode.
 - Automatic collision back-off and frame retransmission.
 - Includes power management by clock switching.
 - Wake-on-LAN power management support allows system wake-up: using the receive filters or a magic frame detection filter.
- Physical interface:
 - Attachment of external PHY chip through standard RMI interface.
 - PHY register access is available via the MIIM interface.

8.12 USB interface

The Universal Serial Bus (USB) is a 4-wire bus that supports communication between a host and one or more (up to 127) peripherals. The host controller allocates the USB bandwidth to attached devices through a token-based protocol. The bus supports hot plugging and dynamic configuration of the devices. All transactions are initiated by the host controller.

The LPC1759/58/56/54 USB interface includes a device, Host, and OTG controller with on-chip PHY for device and Host functions. The OTG switching protocol is supported through the use of an external controller. Details on typical USB interfacing solutions can be found in [Section 15.1](#). The LPC1752/51 include a USB device controller only.

8.12.1 USB device controller

The device controller enables 12 Mbit/s data exchange with a USB Host controller. It consists of a register interface, serial interface engine, endpoint buffer memory, and a DMA controller. The serial interface engine decodes the USB data stream and writes data to the appropriate endpoint buffer. The status of a completed USB transfer or error condition is indicated via status registers. An interrupt is also generated if enabled. When enabled, the DMA controller transfers data between the endpoint buffer and the on-chip SRAM.

8.12.1.1 Features

- Fully compliant with *USB 2.0 specification (full speed)*.
- Supports 32 physical (16 logical) endpoints with a 4 kB endpoint buffer RAM.
- Supports Control, Bulk, Interrupt and Isochronous endpoints.
- Scalable realization of endpoints at run time.
- Endpoint Maximum packet size selection (up to USB maximum specification) by software at run time.
- Supports SoftConnect and GoodLink features.

- While USB is in the Suspend mode, the LPC1759/58/56/54/52/51 can enter one of the reduced power modes and wake up on USB activity.
- Supports DMA transfers with all on-chip SRAM blocks on all non-control endpoints.
- Allows dynamic switching between CPU-controlled slave and DMA modes.
- Double buffer implementation for Bulk and Isochronous endpoints.

8.12.2 USB host controller (LPC1759/58/56/54 only).

The host controller enables full- and low-speed data exchange with USB devices attached to the bus. It consists of a register interface, a serial interface engine, and a DMA controller. The register interface complies with the Open Host Controller Interface (OHCI) specification.

8.12.2.1 Features

- OHCI compliant.
- One downstream port.
- Supports port power switching.

8.12.3 USB OTG controller (LPC1759/58/56/54 only).

USB OTG is a supplement to the USB 2.0 specification that augments the capability of existing mobile devices and USB peripherals by adding host functionality for connection to USB peripherals.

The OTG Controller integrates the host controller, device controller, and a master-only I²C-bus interface to implement OTG dual-role device functionality. The dedicated I²C-bus interface controls an external OTG transceiver.

8.12.3.1 Features

- Fully compliant with *On-The-Go supplement to the USB 2.0 Specification, Revision 1.0a*.
- Hardware support for Host Negotiation Protocol (HNP).
- Includes a programmable timer required for HNP and Session Request Protocol (SRP).
- Supports any OTG transceiver compliant with the *OTG Transceiver Specification (CEA-2011), Rev. 1.0*.

8.13 CAN controller and acceptance filters

The Controller Area Network (CAN) is a serial communications protocol which efficiently supports distributed real-time control with a very high level of security. Its domain of application ranges from high-speed networks to low cost multiplex wiring.

The CAN block is intended to support multiple CAN buses simultaneously, allowing the device to be used as a gateway, switch, or router among a number of CAN buses in industrial or automotive applications.

Remark: LPC1754/52/51 have only one CAN bus.

8.13.1 Features

- One or two CAN controllers and buses.
- Data rates to 1 Mbit/s on each bus.
- 32-bit register and RAM access.
- Compatible with *CAN specification 2.0B, ISO 11898-1*.
- Global Acceptance Filter recognizes standard (11-bit) and extended-frame (29-bit) receive identifiers for all CAN buses.
- Acceptance Filter can provide FullCAN-style automatic reception for selected Standard Identifiers.
- FullCAN messages can generate interrupts.

8.14 12-bit ADC

The LPC1759/58/56/54/52/51 contain one ADC. It is a single 12-bit successive approximation ADC with six channels and DMA support.

8.14.1 Features

- 12-bit successive approximation ADC.
- Input multiplexing among 6 pins.
- Power-down mode.
- Measurement range VREFN to VREFP.
- 12-bit conversion rate: 200 kHz.
- Individual channels can be selected for conversion.
- Burst conversion mode for single or multiple inputs.
- Optional conversion on transition of input pin or Timer Match signal.
- Individual result registers for each ADC channel to reduce interrupt overhead.
- DMA support.

8.15 10-bit DAC (LPC1759/58/56/54 only)

The DAC allows to generate a variable analog output. The maximum output value of the DAC is VREFP.

8.15.1 Features

- 10-bit DAC
- Resistor string architecture
- Buffered output
- Power-down mode
- Selectable output drive
- Dedicated conversion timer
- DMA support

8.16 UARTs

The LPC1759/58/56/54/52/51 each contain four UARTs. In addition to standard transmit and receive data lines, UART1 also provides a full modem control handshake interface and support for RS-485/9-bit mode allowing both software address detection and automatic address detection using 9-bit mode.

The UARTs include a fractional baud rate generator. Standard baud rates such as 115200 Bd can be achieved with any crystal frequency above 2 MHz.

8.16.1 Features

- Maximum UART data bit rate of 6.25 Mbit/s.
- 16 B Receive and Transmit FIFOs.
- Register locations conform to 16C550 industry standard.
- Receiver FIFO trigger points at 1 B, 4 B, 8 B, and 14 B.
- Built-in fractional baud rate generator covering wide range of baud rates without a need for external crystals of particular values.
- Fractional divider for baud rate control, auto baud capabilities and FIFO control mechanism that enables software flow control implementation.
- UART1 equipped with standard modem interface signals. This module also provides full support for hardware flow control (auto-CTS/RTS).
- Support for RS-485/9-bit/EIA-485 mode (UART1).
- UART3 includes an IrDA mode to support infrared communication.
- All UARTs have DMA support.

8.17 SPI serial I/O controller

The LPC1759/58/56/54/52/51 contain one SPI controller. SPI is a full duplex serial interface designed to handle multiple masters and slaves connected to a given bus. Only a single master and a single slave can communicate on the interface during a given data transfer. During a data transfer the master always sends 8 bits to 16 bits of data to the slave, and the slave always sends 8 bits to 16 bits of data to the master.

8.17.1 Features

- Maximum SPI data bit rate of 12.5 Mbit/s
- Compliant with SPI specification
- Synchronous, serial, full duplex communication
- Combined SPI master and slave
- Maximum data bit rate of one eighth of the input clock rate
- 8 bits to 16 bits per transfer

8.18 SSP serial I/O controller

The LPC1759/58/56/54/52/51 contain two SSP controllers. The SSP controller is capable of operation on a SPI, 4-wire SSI, or Microwire bus. It can interact with multiple masters and slaves on the bus. Only a single master and a single slave can communicate on the

bus during a given data transfer. The SSP supports full duplex transfers, with frames of 4 bits to 16 bits of data flowing from the master to the slave and from the slave to the master. In practice, often only one of these data flows carries meaningful data.

8.18.1 Features

- Maximum SSP speed of 33 Mbit/s (master) or 8 Mbit/s (slave)
- Compatible with Motorola SPI, 4-wire Texas Instruments SSI, and National Semiconductor Microwire buses
- Synchronous serial communication
- Master or slave operation
- 8-frame FIFOs for both transmit and receive
- 4-bit to 16-bit frame
- DMA transfers supported by GPDMA

8.19 I²C-bus serial I/O controllers

The LPC1759/58/56/54/52/51 each contain two I²C-bus controllers.

The I²C-bus is bidirectional for inter-IC control using only two wires: a Serial Clock Line (SCL) and a Serial DATA line (SDA). Each device is recognized by a unique address and can operate as either a receiver-only device (e.g., an LCD driver) or a transmitter with the capability to both receive and send information (such as memory). Transmitters and/or receivers can operate in either master or slave mode, depending on whether the chip has to initiate a data transfer or is only addressed. The I²C is a multi-master bus and can be controlled by more than one bus master connected to it.

8.19.1 Features

- I²C1 and I²C2 use standard I/O pins with bit rates of up to 400 kbit/s (Fast I²C-bus).
- Easy to configure as master, slave, or master/slave.
- Programmable clocks allow versatile rate control.
- Bidirectional data transfer between masters and slaves.
- Multi-master bus (no central master).
- Arbitration between simultaneously transmitting masters without corruption of serial data on the bus.
- Serial clock synchronization allows devices with different bit rates to communicate via one serial bus.
- Serial clock synchronization can be used as a handshake mechanism to suspend and resume serial transfer.
- The I²C-bus can be used for test and diagnostic purposes.
- Both I²C-bus controllers support multiple address recognition and a bus monitor mode.

8.20 I²S-bus serial I/O controllers (LPC1759/58/56 only)

The I²S-bus provides a standard communication interface for digital audio applications.

The *I²S-bus specification* defines a 3-wire serial bus using one data line, one clock line, and one word select signal. The basic I²S connection has one master, which is always the master, and one slave. The I²S-bus interface provides a separate transmit and receive channel, each of which can operate as either a master or a slave.

8.20.1 Features

- The interface has separate input/output channels each of which can operate in master or slave mode.
- Capable of handling 8-bit, 16-bit, and 32-bit word sizes.
- Mono and stereo audio data supported.
- The sampling frequency can range from 16 kHz to 96 kHz (16, 22.05, 32, 44.1, 48, 96) kHz.
- Support for an audio master clock.
- Configurable word select period in master mode (separately for I²S input and output).
- Two 8-word FIFO data buffers are provided, one for transmit and one for receive.
- Generates interrupt requests when buffer levels cross a programmable boundary.
- Two DMA requests, controlled by programmable buffer levels. These are connected to the GPDMA block.
- Controls include reset, stop and mute options separately for I²S input and I²S output.

8.21 General purpose 32-bit timers/external event counters

The LPC1759/58/56/54/52/51 include four 32-bit timer/counters. The timer/counter is designed to count cycles of the system derived clock or an externally-supplied clock. It can optionally generate interrupts, generate timed DMA requests, or perform other actions at specified timer values, based on four match registers. Each timer/counter also includes two capture inputs to trap the timer value when an input signal transitions, optionally generating an interrupt.

8.21.1 Features

- A 32-bit timer/counter with a programmable 32-bit prescaler.
- Counter or timer operation.
- One 32-bit capture channel for timer 0 and two capture channels for timer 1. The capture channels can take a snapshot of the timer value when an input signal transitions. A capture event may also generate an interrupt.
- Four 32-bit match registers that allow:
 - Continuous operation with optional interrupt generation on match.
 - Stop timer on match with optional interrupt generation.
 - Reset timer on match with optional interrupt generation.
- Up to four external outputs corresponding to match registers, with the following capabilities:
 - Set LOW on match.
 - Set HIGH on match.
 - Toggle on match.

- Do nothing on match.
- Up to two match registers can be used to generate timed DMA requests.

8.22 Pulse width modulator

The PWM is based on the standard Timer block and inherits all of its features, although only the PWM function is pinned out on the LPC1759/58/56/54/52/51. The Timer is designed to count cycles of the system derived clock and optionally switch pins, generate interrupts or perform other actions when specified timer values occur, based on seven match registers. The PWM function is in addition to these features, and is based on match register events.

The ability to separately control rising and falling edge locations allows the PWM to be used for more applications. For instance, multi-phase motor control typically requires three non-overlapping PWM outputs with individual control of all three pulse widths and positions.

Two match registers can be used to provide a single edge controlled PWM output. One match register (PWMMR0) controls the PWM cycle rate, by resetting the count upon match. The other match register controls the PWM edge position. Additional single edge controlled PWM outputs require only one match register each, since the repetition rate is the same for all PWM outputs. Multiple single edge controlled PWM outputs will all have a rising edge at the beginning of each PWM cycle, when an PWMMR0 match occurs.

Three match registers can be used to provide a PWM output with both edges controlled. Again, the PWMMR0 match register controls the PWM cycle rate. The other match registers control the two PWM edge positions. Additional double edge controlled PWM outputs require only two match registers each, since the repetition rate is the same for all PWM outputs.

With double edge controlled PWM outputs, specific match registers control the rising and falling edge of the output. This allows both positive going PWM pulses (when the rising edge occurs prior to the falling edge), and negative going PWM pulses (when the falling edge occurs prior to the rising edge).

8.22.1 Features

- LPC1759/58/56/54/52/51 has one PWM block with Counter or Timer operation (may use the peripheral clock or one of the capture inputs as the clock source).
- Seven match registers allow up to 6 single edge controlled or 3 double edge controlled PWM outputs, or a mix of both types. The match registers also allow:
 - Continuous operation with optional interrupt generation on match.
 - Stop timer on match with optional interrupt generation.
 - Reset timer on match with optional interrupt generation.
- Supports single edge controlled and/or double edge controlled PWM outputs. Single edge controlled PWM outputs all go high at the beginning of each cycle unless the output is a constant low. Double edge controlled PWM outputs can have either edge occur at any position within a cycle. This allows for both positive going and negative going pulses.

- Pulse period and width can be any number of timer counts. This allows complete flexibility in the trade-off between resolution and repetition rate. All PWM outputs will occur at the same repetition rate.
- Double edge controlled PWM outputs can be programmed to be either positive going or negative going pulses.
- Match register updates are synchronized with pulse outputs to prevent generation of erroneous pulses. Software must 'release' new match values before they can become effective.
- May be used as a standard 32-bit timer/counter with a programmable 32-bit prescaler if the PWM mode is not enabled.

8.23 Motor control PWM

The motor control PWM is a specialized PWM supporting 3-phase motors and other combinations. Feedback inputs are provided to automatically sense rotor position and use that information to ramp speed up or down. At the same time, the motor control PWM is highly configurable for other generalized timing, counting, capture, and compare applications.

8.24 Quadrature Encoder Interface (QEI)

A quadrature encoder, also known as a 2-channel incremental encoder, converts angular displacement into two pulse signals. By monitoring both the number of pulses and the relative phase of the two signals, the user can track the position, direction of rotation, and velocity. In addition, a third channel, or index signal, can be used to reset the position counter. The quadrature encoder interface decodes the digital pulses from a quadrature encoder wheel to integrate position over time and determine direction of rotation. In addition, the QEI can capture the velocity of the encoder wheel.

8.24.1 Features

- Tracks encoder position.
- Increments/decrements depending on direction.
- Programmable for 2× or 4× position counting.
- Velocity capture using built-in timer.
- Velocity compare function with "less than" interrupt.
- Uses 32-bit registers for position and velocity.
- Three position compare registers with interrupts.
- Index counter for revolution counting.
- Index compare register with interrupts.
- Can combine index and position interrupts to produce an interrupt for whole and partial revolution displacement.
- Digital filter with programmable delays for encoder input signals.
- Can accept decoded signal inputs (clk and direction).
- Connected to APB.

8.25 Repetitive Interrupt (RI) timer

The repetitive interrupt timer provides a free-running 32-bit counter which is compared to a selectable value, generating an interrupt when a match occurs. Any bits of the timer/compare can be masked such that they do not contribute to the match detection. The repetitive interrupt timer can be used to create an interrupt that repeats at predetermined intervals.

8.25.1 Features

- 32-bit counter running from PCLK. Counter can be free-running or be reset by a generated interrupt.
- 32-bit compare value.
- 32-bit compare mask. An interrupt is generated when the counter value equals the compare value, after masking. This allows for combinations not possible with a simple compare.

8.26 ARM Cortex-M3 system tick timer

The ARM Cortex-M3 includes a system tick timer (SYSTICK) that is intended to generate a dedicated SYSTICK exception at a 10 ms interval. In the LPC1759/58/56/54/52/51, this timer can be clocked from the internal AHB clock or from a device pin.

8.27 Watchdog timer

The purpose of the watchdog is to reset the microcontroller within a reasonable amount of time if it enters an erroneous state. When enabled, the watchdog will generate a system reset if the user program fails to 'feed' (or reload) the watchdog within a predetermined amount of time.

8.27.1 Features

- Internally resets chip if not periodically reloaded.
- Debug mode.
- Enabled by software but requires a hardware reset or a watchdog reset/interrupt to be disabled.
- Incorrect/Incomplete feed sequence causes reset/interrupt if enabled.
- Flag to indicate watchdog reset.
- Programmable 32-bit timer with internal prescaler.
- Selectable time period from $(T_{cy(WDCLK)} \times 256 \times 4)$ to $(T_{cy(WDCLK)} \times 2^{32} \times 4)$ in multiples of $T_{cy(WDCLK)} \times 4$.
- The Watchdog Clock (WDCLK) source can be selected from the Internal RC (IRC) oscillator, the RTC oscillator, or the APB peripheral clock. This gives a wide range of potential timing choices of Watchdog operation under different power reduction conditions. It also provides the ability to run the WDT from an entirely internal source that is not dependent on an external crystal and its associated components and wiring for increased reliability.
- Includes lock/safe feature.

8.28 RTC and backup registers

The RTC is a set of counters for measuring time when system power is on, and optionally when it is off. The RTC on the LPC1759/58/56/54/52/51 is designed to have extremely low power consumption, i.e. less than 1 μ A. The RTC will typically run from the main chip power supply, conserving battery power while the rest of the device is powered up. When operating from a battery, the RTC will continue working down to 2.1 V. Battery power can be provided from a standard 3 V Lithium button cell.

An ultra-low power 32 kHz oscillator will provide a 1 Hz clock to the time counting portion of the RTC, moving most of the power consumption out of the time counting function.

The RTC includes a calibration mechanism to allow fine-tuning the count rate in a way that will provide less than 1 second per day error when operated at a constant voltage and temperature.

The RTC contains a small set of backup registers (20 bytes) for holding data while the main part of the LPC1759/58/56/54/52/51 is powered off.

The RTC includes an alarm function that can wake up the LPC1759/58/56/54/52/51 from all reduced power modes with a time resolution of 1 s.

8.28.1 Features

- Measures the passage of time to maintain a calendar and clock.
- Ultra low power design to support battery powered systems.
- Provides Seconds, Minutes, Hours, Day of Month, Month, Year, Day of Week, and Day of Year.
- Dedicated power supply pin can be connected to a battery or to the main 3.3 V.
- Periodic interrupts can be generated from increments of any field of the time registers.
- Backup registers (20 bytes) powered by VBAT.
- RTC power supply is isolated from the rest of the chip.

8.29 Clocking and power control

8.29.1 Crystal oscillators

The LPC1759/58/56/54/52/51 include three independent oscillators. These are the main oscillator, the IRC oscillator, and the RTC oscillator. Each oscillator can be used for more than one purpose as required in a particular application. Any of the three clock sources can be chosen by software to drive the main PLL and ultimately the CPU.

Following reset, the LPC1759/58/56/54/52/51 will operate from the Internal RC oscillator until switched by software. This allows systems to operate without any external crystal and the bootloader code to operate at a known frequency.

See [Figure 4](#) for an overview of the LPC1759/58/56/54/52/51 clock generation.

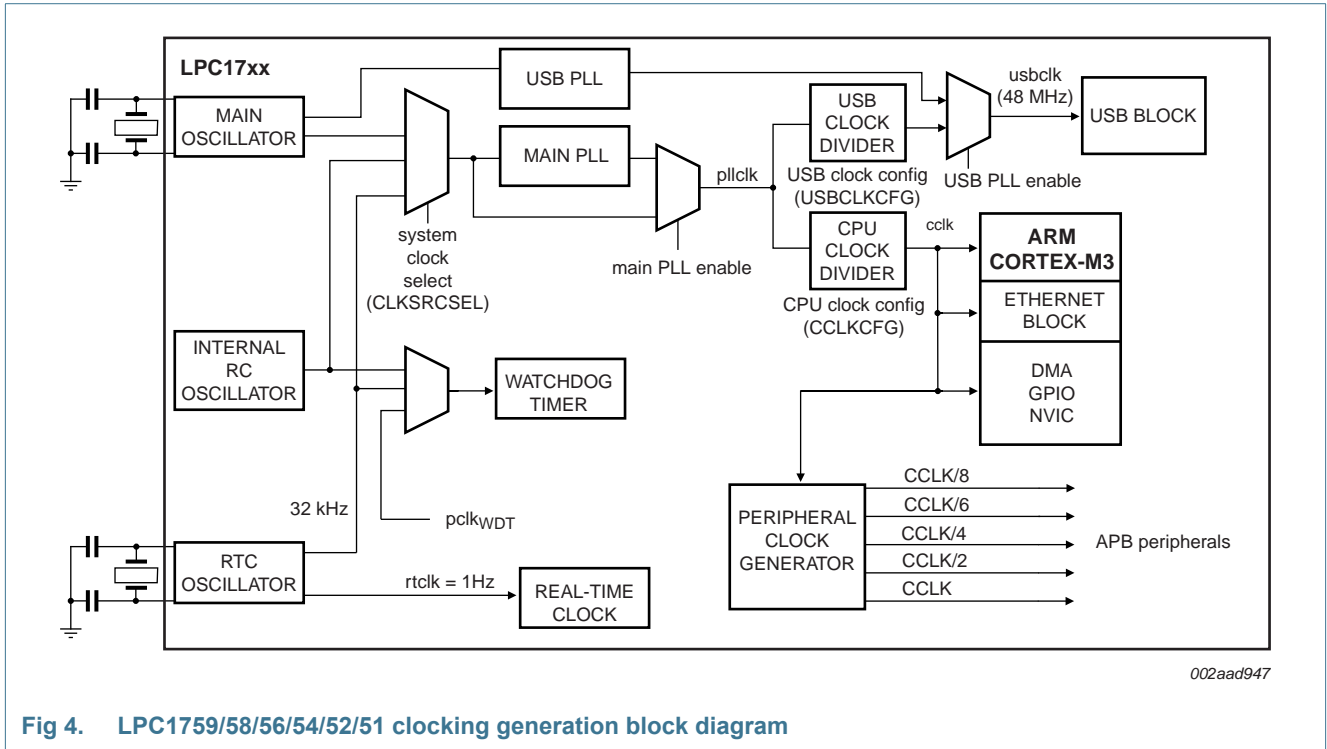


Fig 4. LPC1759/58/56/54/52/51 clocking generation block diagram

8.29.1.1 Internal RC oscillator

The IRC may be used as the clock source for the WDT, and/or as the clock that drives the PLL and subsequently the CPU. The nominal IRC frequency is 4 MHz. The IRC is trimmed to 1 % accuracy over the entire voltage and temperature range.

Upon power-up or any chip reset, the LPC1759/58/56/54/52/51 use the IRC as the clock source. Software may later switch to one of the other available clock sources.

8.29.1.2 Main oscillator

The main oscillator can be used as the clock source for the CPU, with or without using the PLL. The main oscillator also provides the clock source for the dedicated USB PLL.

The main oscillator operates at frequencies of 1 MHz to 25 MHz. This frequency can be boosted to a higher frequency, up to the maximum CPU operating frequency, by the main PLL. The clock selected as the PLL input is PLLCLKIN. The ARM processor clock frequency is referred to as CCLK elsewhere in this document. The frequencies of PLLCLKIN and CCLK are the same value unless the PLL is active and connected. The clock frequency for each peripheral can be selected individually and is referred to as PCLK. Refer to [Section 8.29.2](#) for additional information.

8.29.1.3 RTC oscillator

The RTC oscillator can be used as the clock source for the RTC block, the main PLL, and/or the CPU.

8.29.2 Main PLL (PLL0)

The PLL0 accepts an input clock frequency in the range of 32 kHz to 25 MHz. The input frequency is multiplied up to a high frequency, then divided down to provide the actual clock used by the CPU and/or the USB block.

The PLL0 input, in the range of 32 kHz to 25 MHz, may initially be divided down by a value 'N', which may be in the range of 1 to 256. This input division provides a wide range of output frequencies from the same input frequency.

Following the PLL0 input divider is the PLL0 multiplier. This can multiply the input divider output through the use of a Current Controlled Oscillator (CCO) by a value 'M', in the range of 1 through 32768. The resulting frequency must be in the range of 275 MHz to 550 MHz. The multiplier works by dividing the CCO output by the value of M, then using a phase-frequency detector to compare the divided CCO output to the multiplier input. The error value is used to adjust the CCO frequency.

The PLL0 is turned off and bypassed following a chip Reset and by entering Power-down mode. PLL0 is enabled by software only. The program must configure and activate the PLL0, wait for the PLL0 to lock, and then connect to the PLL0 as a clock source.

8.29.3 USB PLL (PLL1)

The LPC1759/58/56/54/52/51 contain a second, dedicated USB PLL1 to provide clocking for the USB interface.

The PLL1 receives its clock input from the main oscillator only and provides a fixed 48 MHz clock to the USB block only. The PLL1 is disabled and powered off on reset. If the PLL1 is left disabled, the USB clock will be supplied by the 48 MHz clock from the main PLL0.

The PLL1 accepts an input clock frequency in the range of 10 MHz to 25 MHz only. The input frequency is multiplied up the range of 48 MHz for the USB clock using a Current Controlled Oscillators (CCO). It is insured that the PLL1 output has a 50 % duty cycle.

8.29.4 Wake-up timer

The LPC1759/58/56/54/52/51 begin operation at power-up and when awakened from Power-down mode by using the 4 MHz IRC oscillator as the clock source. This allows chip operation to resume quickly. If the main oscillator or the PLL is needed by the application, software will need to enable these features and wait for them to stabilize before they are used as a clock source.

When the main oscillator is initially activated, the wake-up timer allows software to ensure that the main oscillator is fully functional before the processor uses it as a clock source and starts to execute instructions. This is important at power on, all types of Reset, and whenever any of the aforementioned functions are turned off for any reason. Since the oscillator and other functions are turned off during Power-down mode, any wake-up of the processor from Power-down mode makes use of the wake-up Timer.

The Wake-up Timer monitors the crystal oscillator to check whether it is safe to begin code execution. When power is applied to the chip, or when some event caused the chip to exit Power-down mode, some time is required for the oscillator to produce a signal of sufficient amplitude to drive the clock logic. The amount of time depends on many factors, including the rate of $V_{DD(3V3)}$ ramp (in the case of power on), the type of crystal and its

electrical characteristics (if a quartz crystal is used), as well as any other external circuitry (e.g., capacitors), and the characteristics of the oscillator itself under the existing ambient conditions.

8.29.5 Power control

The LPC1759/58/56/54/52/51 support a variety of power control features. There are four special modes of processor power reduction: Sleep mode, Deep-sleep mode, Power-down mode, and Deep power-down mode. The CPU clock rate may also be controlled as needed by changing clock sources, reconfiguring PLL values, and/or altering the CPU clock divider value. This allows a trade-off of power versus processing speed based on application requirements. In addition, Peripheral Power Control allows shutting down the clocks to individual on-chip peripherals, allowing fine tuning of power consumption by eliminating all dynamic power use in any peripherals that are not required for the application. Each of the peripherals has its own clock divider which provides even better power control.

Integrated PMU (Power Management Unit) automatically adjust internal regulators to minimize power consumption during Sleep, Deep sleep, Power-down, and Deep power-down modes.

The LPC1759/58/56/54/52/51 also implement a separate power domain to allow turning off power to the bulk of the device while maintaining operation of the RTC and a small set of registers for storing data during any of the power-down modes.

8.29.5.1 Sleep mode

When Sleep mode is entered, the clock to the core is stopped. Resumption from the Sleep mode does not need any special sequence but re-enabling the clock to the ARM core.

In Sleep mode, execution of instructions is suspended until either a Reset or interrupt occurs. Peripheral functions continue operation during Sleep mode and may generate interrupts to cause the processor to resume execution. Sleep mode eliminates dynamic power used by the processor itself, memory systems and related controllers, and internal buses.

8.29.5.2 Deep-sleep mode

In Deep-sleep mode, the oscillator is shut down and the chip receives no internal clocks. The processor state and registers, peripheral registers, and internal SRAM values are preserved throughout Deep-sleep mode and the logic levels of chip pins remain static. The output of the IRC is disabled but the IRC is not powered down for a fast wake-up later. The RTC oscillator is not stopped because the RTC interrupts may be used as the wake-up source. The PLL is automatically turned off and disconnected. The CCLK and USB clock dividers automatically get reset to zero.

The Deep-sleep mode can be terminated and normal operation resumed by either a Reset or certain specific interrupts that are able to function without clocks. Since all dynamic operation of the chip is suspended, Deep-sleep mode reduces chip power consumption to a very low value. Power to the flash memory is left on in Deep-sleep mode, allowing a very quick wake-up.

On wake-up from Deep-sleep mode, the code execution and peripherals activities will resume after 4 cycles expire if the IRC was used before entering Deep-sleep mode. If the main external oscillator was used, the code execution will resume when 4096 cycles expire. PLL and clock dividers need to be reconfigured accordingly.

8.29.5.3 Power-down mode

Power-down mode does everything that Deep-sleep mode does, but also turns off the power to the IRC oscillator and the flash memory. This saves more power but requires waiting for resumption of flash operation before execution of code or data access in the flash memory can be accomplished.

On the wake-up of Power-down mode, if the IRC was used before entering Power-down mode, it will take IRC 60 μ s to start-up. After this 4 IRC cycles will expire before the code execution can then be resumed if the code was running from SRAM. In the meantime, the flash wake-up timer then counts 4 MHz IRC clock cycles to make the 100 μ s flash start-up time. When it times out, access to the flash will be allowed. Users need to reconfigure the PLL and clock dividers accordingly.

8.29.5.4 Deep power-down mode

The Deep power-down mode can only be entered from the RTC block. In Deep power-down mode, power is shut off to the entire chip with the exception of the RTC module and the $\overline{\text{RESET}}$ pin.

The LPC1759/58/56/54/52/51 can wake up from Deep power-down mode via the $\overline{\text{RESET}}$ pin or an alarm match event of the RTC.

8.29.5.5 Wakeup interrupt controller

The Wakeup Interrupt Controller (WIC) allows the CPU to automatically wake up from any enabled priority interrupt that can occur while the clocks are stopped in Deep sleep, Power-down, and Deep power-down modes.

The Wakeup Interrupt Controller (WIC) works in connection with the Nested Vectored Interrupt Controller (NVIC). When the CPU enters Deep sleep, Power-down, or Deep power-down mode, the NVIC sends a mask of the current interrupt situation to the WIC. This mask includes all of the interrupts that are both enabled and of sufficient priority to be serviced immediately. With this information, the WIC simply notices when one of the interrupts has occurred and then it wakes up the CPU.

The Wakeup Interrupt Controller (WIC) eliminates the need to periodically wake up the CPU and poll the interrupts resulting in additional power savings.

8.29.6 Peripheral power control

A power control for peripherals feature allows individual peripherals to be turned off if they are not needed in the application, resulting in additional power savings.

8.29.7 Power domains

The LPC1759/58/56/54/52/51 provide two independent power domains that allow the bulk of the device to have power removed while maintaining operation of the RTC and the backup Registers.

On the LPC1759/58/56/54/52/51, I/O pads are powered by the 3.3 V ($V_{DD(3V3)}$) pins, while the $V_{DD(REG)(3V3)}$ pin powers the on-chip voltage regulator which in turn provides power to the CPU and most of the peripherals.

Depending on the LPC1759/58/56/54/52/51 application, a design can use two power options to manage power consumption.

The first option assumes that power consumption is not a concern and the design ties the $V_{DD(3V3)}$ and $V_{DD(REG)(3V3)}$ pins together. This approach requires only one 3.3 V power supply for both pads, the CPU, and peripherals. While this solution is simple, it does not support powering down the I/O pad ring “on the fly” while keeping the CPU and peripherals alive.

The second option uses two power supplies; a 3.3 V supply for the I/O pads ($V_{DD(3V3)}$) and a dedicated 3.3 V supply for the CPU ($V_{DD(REG)(3V3)}$). Having the on-chip voltage regulator powered independently from the I/O pad ring enables shutting down of the I/O pad power supply “on the fly”, while the CPU and peripherals stay active.

The VBAT pin supplies power only to the RTC domain. The RTC requires a minimum of power to operate, which can be supplied by an external battery. The device core power ($V_{DD(REG)(3V3)}$) is used to operate the RTC whenever $V_{DD(REG)(3V3)}$ is present. Therefore, there is no power drain from the RTC battery when $V_{DD(REG)(3V3)}$ is available.

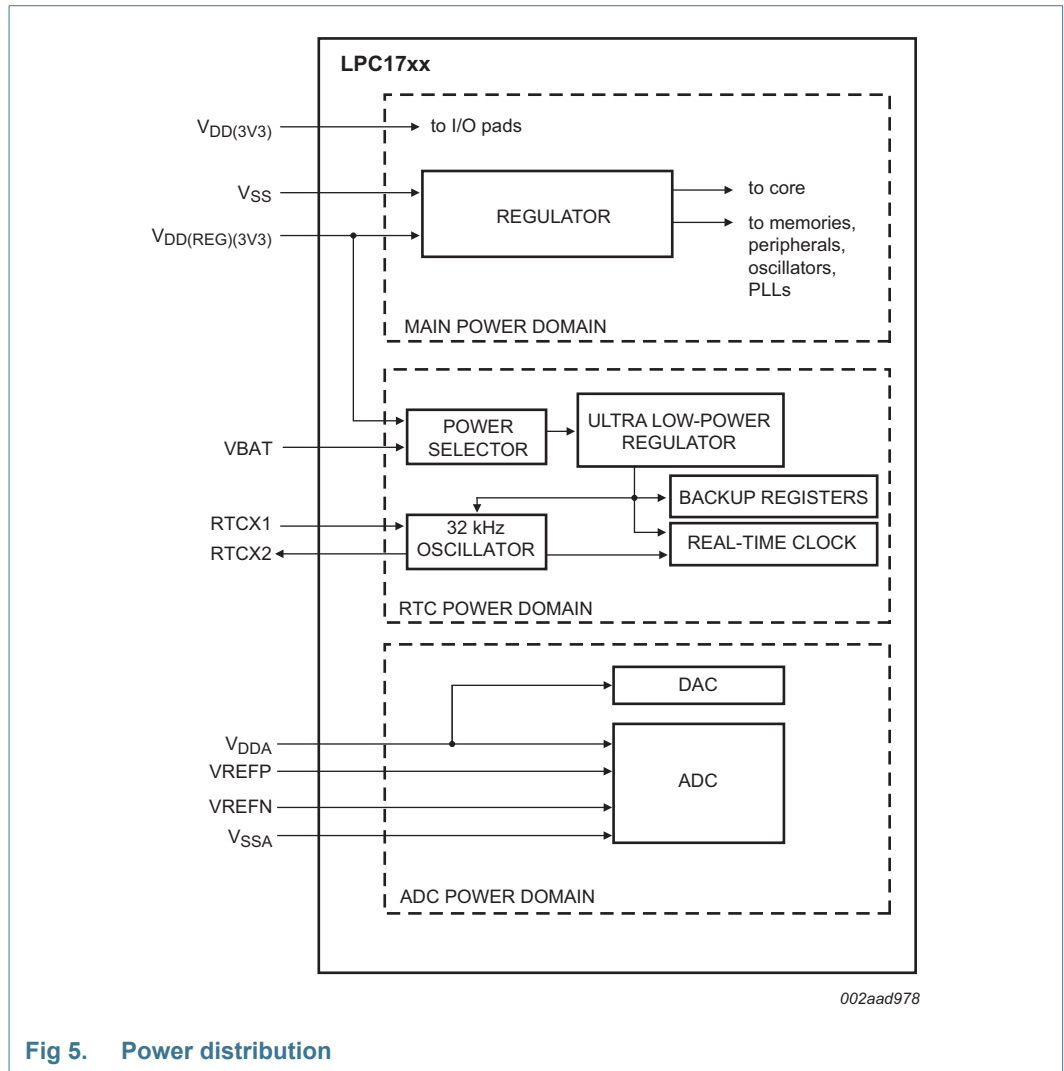


Fig 5. Power distribution

8.30 System control

8.30.1 Reset

Reset has four sources on the LPC17xx: the $\overline{\text{RESET}}$ pin, the Watchdog reset, power-on reset (POR), and the BrownOut Detection (BOD) circuit. The $\overline{\text{RESET}}$ pin is a Schmitt trigger input pin. Assertion of chip Reset by any source, once the operating voltage attains a usable level, causes the $\overline{\text{RSTOUT}}$ pin to go LOW and starts the wake-up timer (see description in [Section 8.29.4](#)). The wake-up timer ensures that reset remains asserted until the external Reset is de-asserted, the oscillator is running, a fixed number of clocks have passed, and the flash controller has completed its initialization. Once reset is de-asserted, or, in case of a BOD-triggered reset, once the voltage rises above the BOD threshold, the $\overline{\text{RSTOUT}}$ pin goes HIGH.

When the internal Reset is removed, the processor begins executing at address 0, which is initially the Reset vector mapped from the boot block. At that point, all of the processor and peripheral registers have been initialized to predetermined values.

8.30.2 Brownout detection

The LPC1759/58/56/54/52/51 include 2-stage monitoring of the voltage on the $V_{DD(REG)(3V3)}$ pins. If this voltage falls below 2.2 V, the BOD asserts an interrupt signal to the Vectored Interrupt Controller. This signal can be enabled for interrupt in the Interrupt Enable Register in the NVIC in order to cause a CPU interrupt; if not, software can monitor the signal by reading a dedicated status register.

The second stage of low-voltage detection asserts reset to inactivate the LPC1759/58/56/54/52/51 when the voltage on the $V_{DD(REG)(3V3)}$ pins falls below 1.85 V. This reset prevents alteration of the flash as operation of the various elements of the chip would otherwise become unreliable due to low voltage. The BOD circuit maintains this reset down below 1 V, at which point the power-on reset circuitry maintains the overall reset.

Both the 2.2 V and 1.85 V thresholds include some hysteresis. In normal operation, this hysteresis allows the 2.2 V detection to reliably interrupt, or a regularly executed event loop to sense the condition.

8.30.3 Code security (Code Read Protection - CRP)¹

This feature of the LPC1759/58/56/54/52/51 allows user to enable different levels of security in the system so that access to the on-chip flash and use of the JTAG and ISP can be restricted. When needed, CRP is invoked by programming a specific pattern into a dedicated flash location. IAP commands are not affected by the CRP.

There are three levels of the Code Read Protection.

CRP1 disables access to chip via the JTAG and allows partial flash update (excluding flash sector 0) using a limited set of the ISP commands. This mode is useful when CRP is required and flash field updates are needed but all sectors can not be erased.

CRP2 disables access to chip via the JTAG and only allows full flash erase and update using a reduced set of the ISP commands.

Running an application with level CRP3 selected fully disables any access to chip via the JTAG pins and the ISP. This mode effectively disables ISP override using P2[10] pin, too. It is up to the user's application to provide (if needed) flash update mechanism using IAP calls or call reinvoke ISP command to enable flash update via UART0.

CAUTION



If level three Code Read Protection (CRP3) is selected, no future factory testing can be performed on the device.

8.30.4 APB interface

The APB peripherals are split into two separate APB buses in order to distribute the bus bandwidth and thereby reducing stalls caused by contention between the CPU and the GPDMA controller.

1. LPC1751FBD80 with device ID 25001110 does not support CRP feature. LPC1751FBD80 with device ID 25001118 does support CRP. See errata note in ES_LPC1751.

8.30.5 AHB multilayer matrix

The LPC1759/58/56/54/52/51 use an AHB multilayer matrix. This matrix connects the instruction (I-code) and data (D-code) CPU buses of the ARM Cortex-M3 to the flash memory, the main (32 kB) static RAM, and the Boot ROM. The GPDMA can also access all of these memories. The peripheral DMA controllers, Ethernet (LPC1758 only) and USB, can access all SRAM blocks. Additionally, the matrix connects the CPU system bus and all of the DMA controllers to the various peripheral functions.

8.30.6 External interrupt inputs

The LPC1759/58/56/54/52/51 include up to 30 edge sensitive interrupt inputs combined with one level sensitive external interrupt input as selectable pin function. The external interrupt input can optionally be used to wake up the processor from Power-down mode.

8.30.7 Memory mapping control

The Cortex-M3 incorporates a mechanism that allows remapping the interrupt vector table to alternate locations in the memory map. This is controlled via the Vector Table Offset Register contained in the NVIC.

The vector table may be located anywhere within the bottom 1 GB of Cortex-M3 address space. The vector table must be located on a 128 word (512 byte) boundary because the NVIC on the LPC1759/58/56/54/52/51 is configured for 128 total interrupts.

8.31 Emulation and debugging

Debug and trace functions are integrated into the ARM Cortex-M3. Serial wire debug and trace functions are supported in addition to a standard JTAG debug and parallel trace functions. The ARM Cortex-M3 is configured to support up to eight breakpoints and four watch points.

9. Limiting values

Table 5. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).^[1]

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---------------------------|---------------------------------------|--|--------|-------|-------|------|
| V _{DD(3V3)} | supply voltage (3.3 V) | external rail | [2] | -0.5 | +4.6 | V |
| V _{DD(REG)(3V3)} | regulator supply voltage (3.3 V) | | [2] | -0.5 | +4.6 | V |
| V _{DDA} | analog 3.3 V pad supply voltage | | [2] | -0.5 | +4.6 | V |
| V _{i(VBAT)} | input voltage on pin VBAT | for the RTC | [2] | -0.5 | +4.6 | V |
| V _{i(VREFP)} | input voltage on pin VREFP | | [2] | -0.5 | +4.6 | V |
| V _{IA} | analog input voltage | on ADC related pins | [2][3] | -0.5 | +5.1 | V |
| V _I | input voltage | 5 V tolerant digital I/O pins; V _{DD} ≥ 2.4 V | [2][4] | -0.5 | +5.5 | V |
| | | V _{DD} = 0 V | | -0.5 | +3.6 | |
| I _{DD} | supply current | per supply pin | | - | 100 | mA |
| I _{SS} | ground current | per ground pin | | - | 100 | mA |
| I _{latch} | I/O latch-up current | -0.5V _{DD(3V3)} < V _I < (1.5V _{DD(3V3)}); T _J < 125 °C | | - | 100 | mA |
| T _{stg} | storage temperature | | [5] | -65 | +150 | °C |
| T _{J(max)} | maximum junction temperature | | | | 150 | °C |
| P _{tot(pack)} | total power dissipation (per package) | based on package heat transfer, not device power consumption | | - | 1.5 | W |
| V _{ESD} | electrostatic discharge voltage | human body model; all pins | [6] | -4000 | +4000 | V |

[1] The following applies to the limiting values:

- a) This product includes circuitry specifically designed for the protection of its internal devices from the damaging effects of excessive static charge. Nonetheless, it is suggested that conventional precautions be taken to avoid applying greater than the rated maximum.
 - b) Parameters are valid over operating temperature range unless otherwise specified. All voltages are with respect to V_{SS} unless otherwise noted.
 - c) The limiting values are stress ratings only. Operating the part at these values is not recommended, and proper operation is not guaranteed. The conditions for functional operation are specified in [Table 7](#).
- [2] Maximum/minimum voltage above the maximum operating voltage (see [Table 7](#)) and below ground that can be applied for a short time (< 10 ms) to a device without leading to irrecoverable failure. Failure includes the loss of reliability and shorter lifetime of the device.
- [3] See [Table 18](#) for maximum operating voltage.
- [4] Including voltage on outputs in 3-state mode.
- [5] The maximum non-operating storage temperature is different than the temperature for required shelf life which should be determined based on required shelf lifetime. Please refer to the JEDEC spec (J-STD-033B.1) for further details.
- [6] Human body model: equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor.

10. Thermal characteristics

10.1 Thermal characteristics

The average chip junction temperature, T_J (°C), can be calculated using the following equation:

$$T_J = T_{amb} + (P_D \times R_{th(j-a)}) \quad (1)$$

- T_{amb} = ambient temperature (°C),
- $R_{th(j-a)}$ = the package junction-to-ambient thermal resistance (°C/W)
- P_D = sum of internal and I/O power dissipation

The internal power dissipation is the product of I_{DD} and V_{DD} . The I/O power dissipation of the I/O pins is often small and many times can be negligible. However it can be significant in some applications.

Table 6. Thermal resistance ($\pm 15\%$)

| Symbol | Parameter | Conditions | Max/Min | Unit |
|---------------|---|---|---------|------|
| LQFP80 | | | | |
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | JEDEC (4.5 in × 4 in); still air | 39.46 | °C/W |
| | | Single-layer (4.5 in × 3 in); still air | 59.39 | °C/W |
| $R_{th(j-c)}$ | thermal resistance from junction to case | | 6.769 | °C/W |

11. Static characteristics

Table 7. Static characteristics

$T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$, unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ ^[1] | Max | Unit | |
|--------------------|----------------------------------|---|------------|--------------------|-----------|------|---------------|
| Supply pins | | | | | | | |
| $V_{DD(3V3)}$ | supply voltage (3.3 V) | external rail | [2] 2.4 | 3.3 | 3.6 | V | |
| $V_{DD(REG)(3V3)}$ | regulator supply voltage (3.3 V) | | 2.4 | 3.3 | 3.6 | V | |
| V_{DDA} | analog 3.3 V pad supply voltage | | [3][4] 2.5 | 3.3 | 3.6 | V | |
| $V_{i(VBAT)}$ | input voltage on pin VBAT | | [5] 2.1 | 3.3 | 3.6 | V | |
| $V_{i(VREFP)}$ | input voltage on pin VREFP | | [3] 2.5 | 3.3 | V_{DDA} | V | |
| $I_{DD(REG)(3V3)}$ | regulator supply current (3.3 V) | active mode; code while(1){} executed from flash; all peripherals disabled; PCLK = $CCLK/8$ | | | | | |
| | | CCLK = 12 MHz; PLL disabled | [6][7] | - | 7 | - | mA |
| | | CCLK = 100 MHz; PLL enabled | [6][7] | - | 42 | - | mA |
| | | CCLK = 100 MHz; PLL enabled (LPC1759) | [6][8] | - | 50 | - | |
| | | CCLK = 120 MHz; PLL enabled (LPC1759) | [6][8] | - | 67 | - | mA |
| | | sleep mode | [6][9] | - | 2 | - | mA |
| | | deep sleep mode | [6][10] | - | 240 | - | μA |
| | | power-down mode | [6][10] | - | 31 | - | μA |
| | | deep power-down mode; RTC running | [11] | - | 630 | - | nA |
| I_{BAT} | battery supply current | Deep power-down mode; RTC running | | | | | |
| | | $V_{DD(REG)(3V3)}$ present | [12] | - | 530 | - | nA |
| | | $V_{DD(REG)(3V3)}$ not present | [13] | - | 1.1 | - | μA |
| $I_{DD(IO)}$ | I/O supply current | deep sleep mode | [14][15] | - | 40 | - | nA |
| | | power-down mode | [14][15] | - | 40 | - | nA |
| | | deep power-down mode | [14] | - | 10 | - | nA |

Table 7. Static characteristics ...continued

 $T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$, unless otherwise specified.

| Symbol | Parameter | Conditions | | Min | Typ ^[1] | Max | Unit |
|----------------------------------|---|--|------------------|---------------------|--------------------|------------------|---------------|
| $I_{DD(ADC)}$ | ADC supply current | active mode; | [16][17] | - | 1.95 | - | mA |
| | | ADC powered | | | | | |
| | | ADC in Power-down mode | [16][18] | - | <0.2 | - | μA |
| | | Deep sleep mode | [16] | - | 38 | - | nA |
| | | Power-down mode | [16] | - | 38 | - | nA |
| $I_{I(ADC)}$ | ADC input current | on pin VREFP | | | | | |
| | | Deep sleep mode | [19] | - | 100 | - | nA |
| | | Power-down mode | [19] | - | 100 | - | nA |
| | | Deep power-down mode | [19] | - | 100 | - | nA |
| Standard port pins, RESET | | | | | | | |
| I_{IL} | LOW-level input current | $V_I = 0\text{ V}$; on-chip pull-up resistor disabled | | - | 0.5 | 10 | nA |
| I_{IH} | HIGH-level input current | $V_I = V_{DD(3V3)}$; on-chip pull-down resistor disabled | | - | 0.5 | 10 | nA |
| I_{OZ} | OFF-state output current | $V_O = 0\text{ V}$; $V_O = V_{DD(3V3)}$; on-chip pull-up/down resistors disabled | | - | 0.5 | 10 | nA |
| V_I | input voltage | pin configured to provide a digital function | [20][21] [22] | 0 | - | 5.0 | V |
| V_O | output voltage | output active | | 0 | - | $V_{DD(3V3)}$ | V |
| V_{IH} | HIGH-level input voltage | | | $0.7V_{DD(3V3)}$ | - | - | V |
| V_{IL} | LOW-level input voltage | | | - | - | $0.3V_{DD(3V3)}$ | V |
| V_{hys} | hysteresis voltage | | | 0.4 | - | - | V |
| V_{OH} | HIGH-level output voltage | $I_{OH} = -4\text{ mA}$ | | $V_{DD(3V3)} - 0.4$ | - | - | V |
| V_{OL} | LOW-level output voltage | $I_{OL} = 4\text{ mA}$ | | - | - | 0.4 | V |
| I_{OH} | HIGH-level output current | $V_{OH} = V_{DD(3V3)} - 0.4\text{ V}$ | | -4 | - | - | mA |
| I_{OL} | LOW-level output current | $V_{OL} = 0.4\text{ V}$ | | 4 | - | - | mA |
| I_{OHS} | HIGH-level short-circuit output current | $V_{OH} = 0\text{ V}$ | [23] | - | - | -45 | mA |
| I_{OLS} | LOW-level short-circuit output current | $V_{OL} = V_{DD(3V3)}$ | [23] | - | - | 50 | mA |
| I_{pd} | pull-down current | $V_I = 5\text{ V}$ | | 10 | 50 | 150 | μA |
| I_{pu} | pull-up current | $V_I = 0\text{ V}$ | | -15 | -50 | -85 | μA |
| | | $V_{DD(3V3)} < V_I < 5\text{ V}$ | | 0 | 0 | 0 | μA |

Table 7. Static characteristics ...continued

 $T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$, unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ ^[1] | Max | Unit | |
|------------------------|--|--|---------|--------------------|----------|---------------|----------|
| Oscillator pins | | | | | | | |
| $V_{i(XTAL1)}$ | input voltage on pin XTAL1 | | -0.5 | 1.8 | 1.95 | V | |
| $V_{o(XTAL2)}$ | output voltage on pin XTAL2 | | -0.5 | 1.8 | 1.95 | V | |
| $V_{i(RTCX1)}$ | input voltage on pin RTCX1 | | -0.5 | - | 3.6 | V | |
| $V_{o(RTCX2)}$ | output voltage on pin RTCX2 | | -0.5 | - | 3.6 | V | |
| USB pins | | | | | | | |
| I_{OZ} | OFF-state output current | $0\text{ V} < V_I < 3.3\text{ V}$ | [2] | - | ± 10 | μA | |
| V_{BUS} | bus supply voltage | | [2] | - | 5.25 | V | |
| V_{DI} | differential input sensitivity voltage | $ (D+) - (D-) $ | [2] | 0.2 | - | V | |
| V_{CM} | differential common mode voltage range | includes V_{DI} range | [2] | 0.8 | - | 2.5 | V |
| $V_{th(rs)se}$ | single-ended receiver switching threshold voltage | | [2] | 0.8 | - | 2.0 | V |
| V_{OL} | LOW-level output voltage for low-/full-speed | R_L of 1.5 k Ω to 3.6 V | [2] | - | - | 0.18 | V |
| V_{OH} | HIGH-level output voltage (driven) for low-/full-speed | R_L of 15 k Ω to GND | [2] | 2.8 | - | 3.5 | V |
| C_{trans} | transceiver capacitance | pin to GND | [2] | - | - | 20 | pF |
| Z_{DRV} | driver output impedance for driver which is not high-speed capable | with 33 Ω series resistor; steady state drive | [2][24] | 36 | - | 44.1 | Ω |

[1] Typical ratings are not guaranteed. The values listed are at room temperature (25 °C), nominal supply voltages.

[2] For USB operation $3.0\text{ V} \leq V_{DD(3V3)} \leq 3.6\text{ V}$. Guaranteed by design.

[3] V_{DDA} and V_{REFP} should be tied to $V_{DD(3V3)}$ if the ADC and DAC are not used.

[4] V_{DDA} for DAC specs are from 2.7 V to 3.6 V.

[5] The RTC typically fails when $V_{i(VBAT)}$ drops below 1.6 V.

[6] $V_{DD(REG)(3V3)} = 3.3\text{ V}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$ for all power consumption measurements.

[7] Applies to LPC1758, LPC1756, LPC1754, LPC1752, LPC1751.

[8] Applies to LPC1759 only.

[9] IRC running at 4 MHz; main oscillator and PLL disabled; $PCLK = \frac{CCLK}{8}$.

[10] BOD disabled.

[11] On pin $V_{DD(REG)(3V3)}$. $I_{BAT} = 530\text{ nA}$. $V_{DD(REG)(3V3)} = 3.0\text{ V}$; $V_{BAT} = 3.0\text{ V}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$.

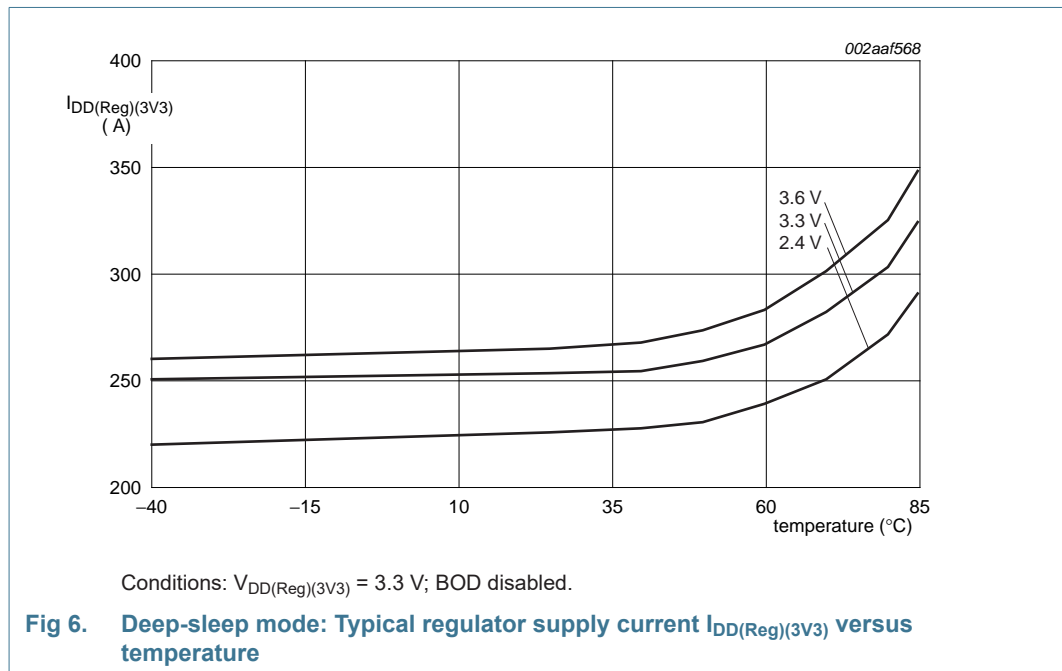
[12] On pin VBAT. $I_{DD(REG)(3V3)} = 630\text{ nA}$. $V_{DD(REG)(3V3)} = 3.0\text{ V}$; $V_{BAT} = 3.0\text{ V}$. $T_{amb} = 25\text{ }^{\circ}\text{C}$.

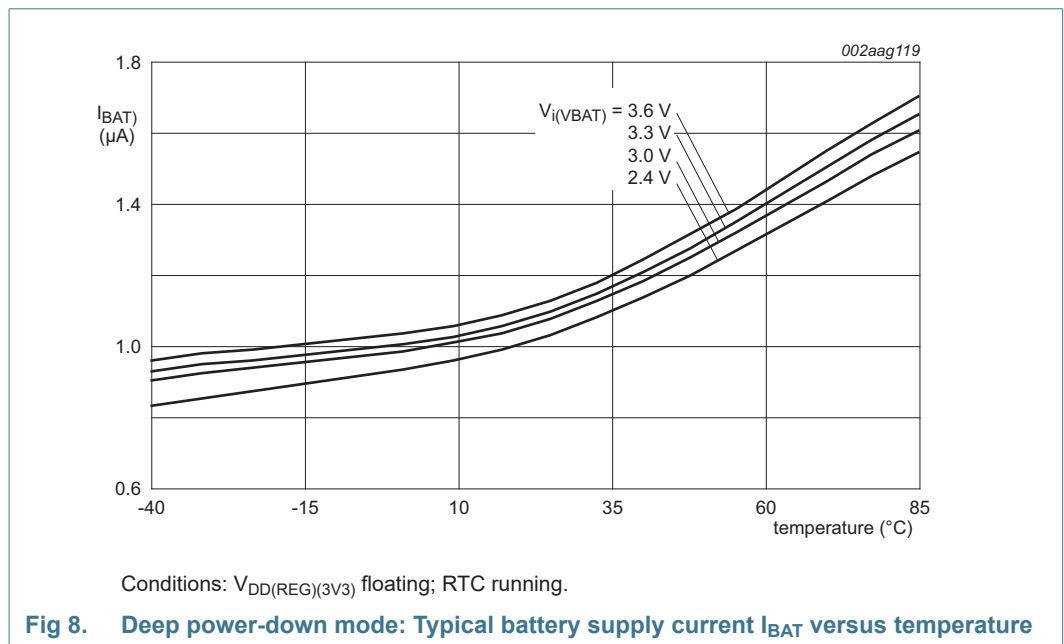
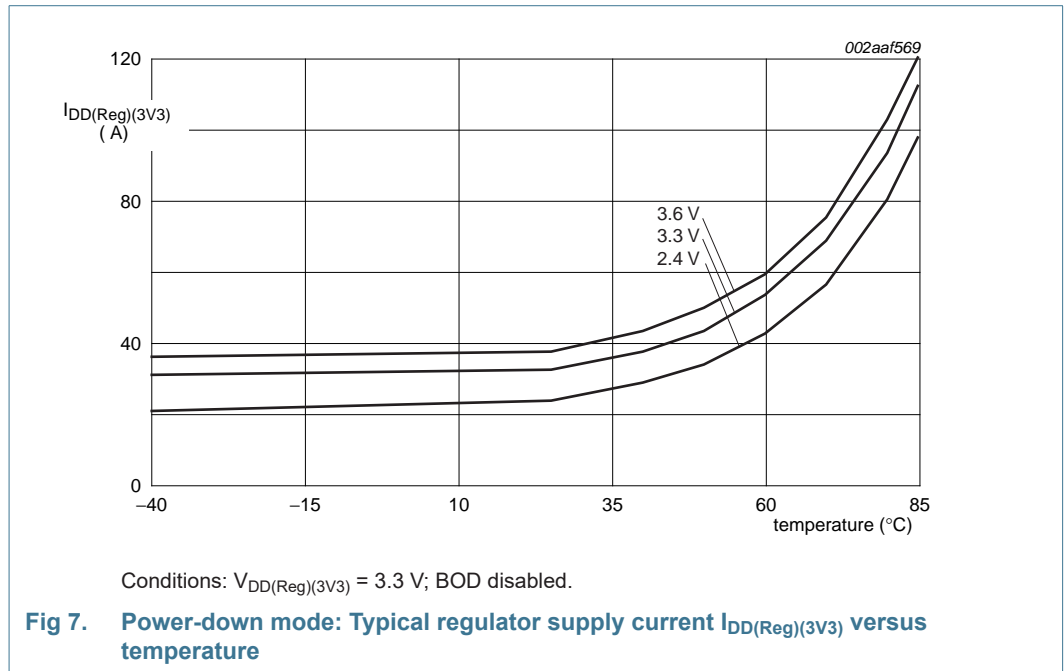
[13] On pin VBAT. $V_{BAT} = 3.0\text{ V}$. $T_{amb} = 25\text{ }^{\circ}\text{C}$.

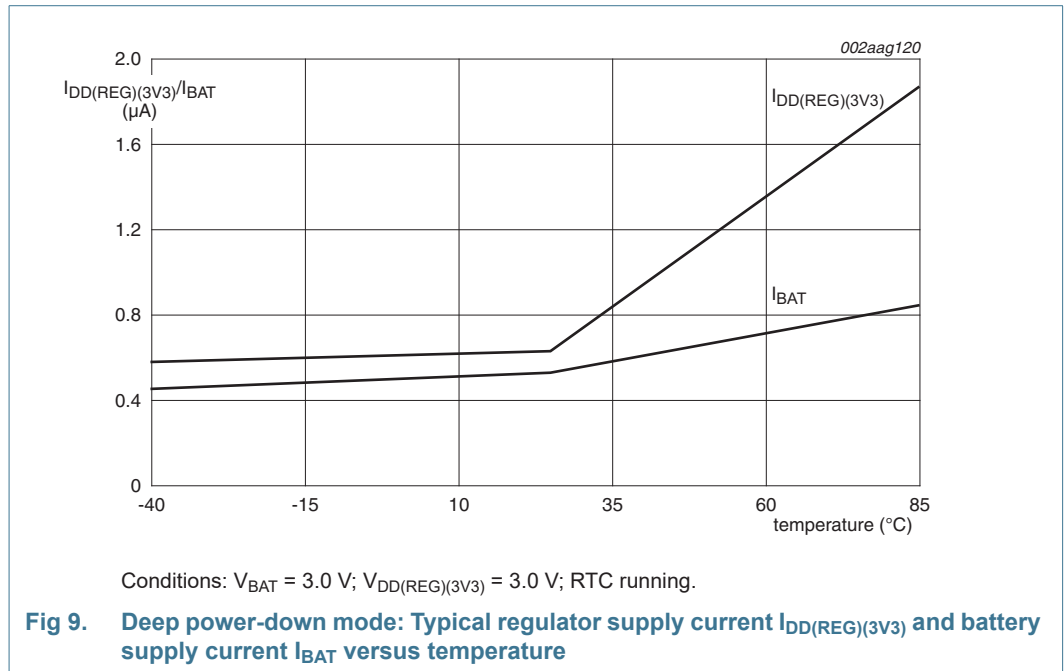
[14] All internal pull-ups disabled. All pins configured as output and driven LOW. $V_{DD(3V3)} = 3.3\text{ V}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$.

- [15] TCK/SWDCLK pin needs to be externally pulled LOW.
- [16] $V_{DDA} = 3.3\text{ V}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$.
- [17] The ADC is powered if the PDN bit in the AD0CR register is set to 1. See *LPC17xx user manual UM10360*.
- [18] The ADC is in Power-down mode if the PDN bit in the AD0CR register is set to 0. See *LPC17xx user manual UM10360*.
- [19] $V_{i(VREFP)} = 3.3\text{ V}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$.
- [20] Including voltage on outputs in 3-state mode.
- [21] $V_{DD(3V3)}$ supply voltage $\geq 2.4\text{ V}$.
- [22] 3-state outputs go into 3-state mode in Deep power-down mode.
- [23] Allowed as long as the current limit does not exceed the maximum current allowed by the device.
- [24] Includes external resistors of $33\ \Omega \pm 1\%$ on D+ and D-.

11.1 Power consumption







11.2 Peripheral power consumption

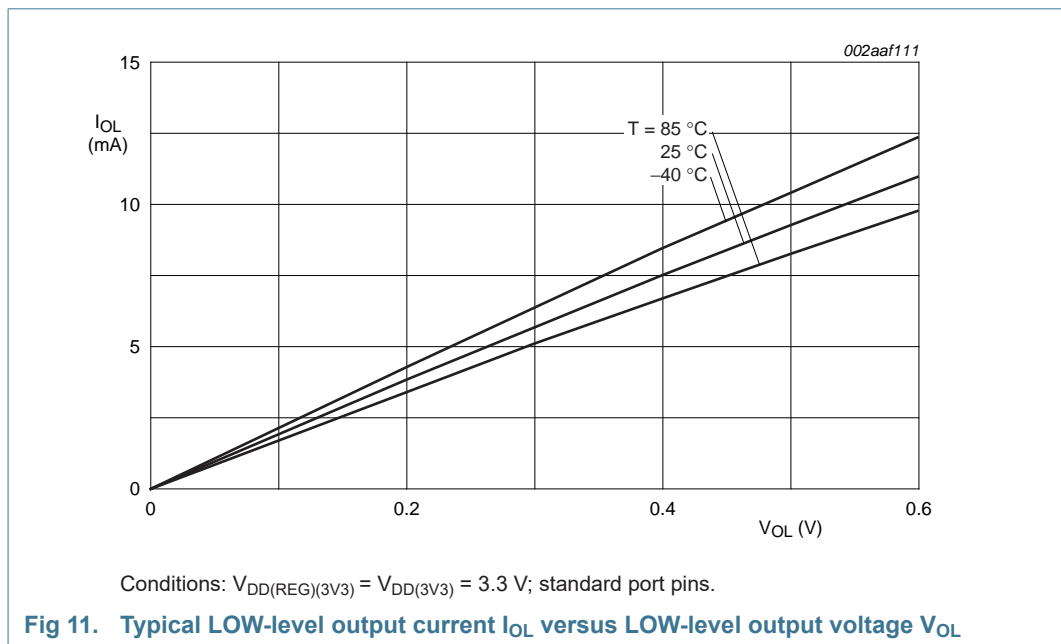
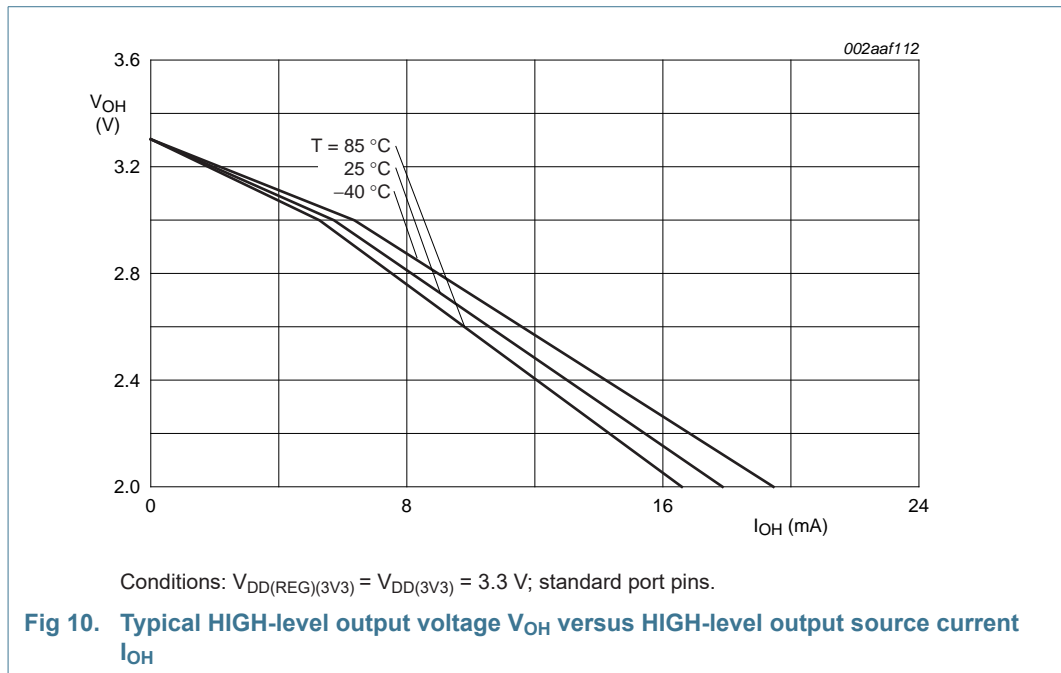
The supply current per peripheral is measured as the difference in supply current between the peripheral block enabled and the peripheral block disabled in the PCONP register. All other blocks are disabled and no code is executed. Measured on a typical sample at $T_{amb} = 25\text{ }^{\circ}\text{C}$. The peripheral clock PCLK = CCLK/4.

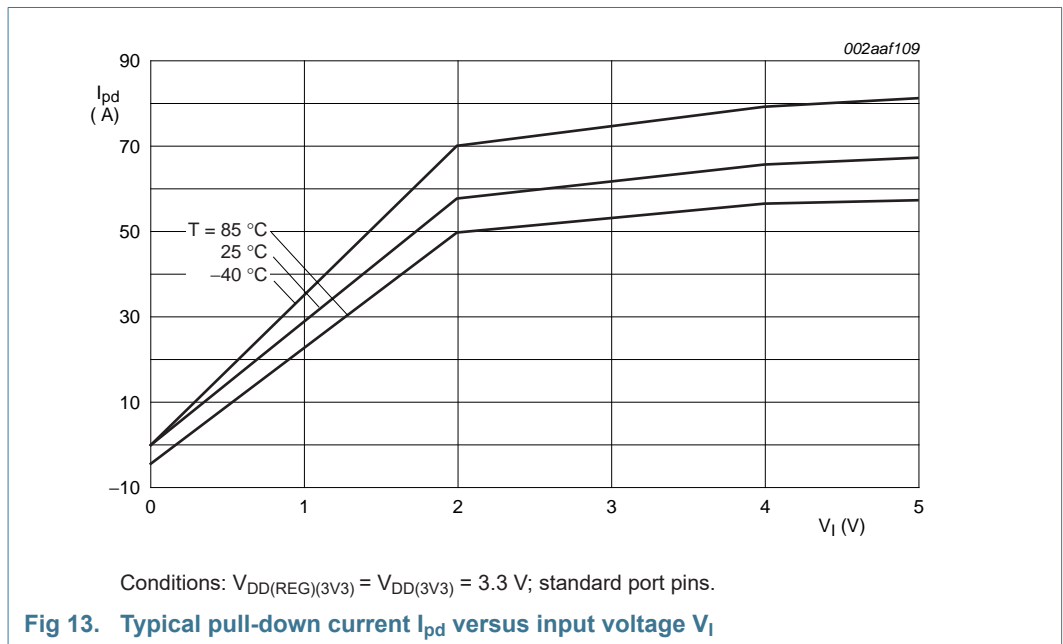
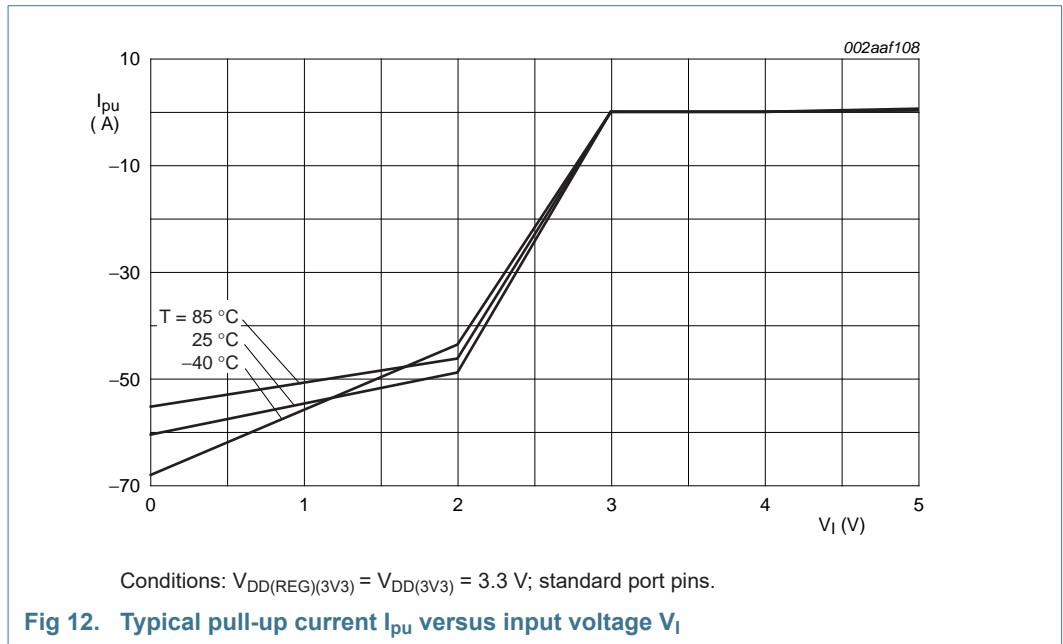
Table 8. Power consumption for individual analog and digital blocks

| Peripheral | Conditions | Typical supply current in mA; CCLK = | | | Notes |
|-------------------------------|--|---|--------|---------|--|
| | | 12 MHz | 48 MHz | 100 MHz | |
| Timer | | 0.03 | 0.11 | 0.23 | Average current per timer |
| UART | | 0.07 | 0.26 | 0.53 | Average current per UART |
| PWM | | 0.05 | 0.20 | 0.41 | |
| Motor control PWM | | 0.05 | 0.21 | 0.42 | |
| I2C | | 0.02 | 0.08 | 0.16 | Average current per I2C |
| SPI | | 0.02 | 0.06 | 0.13 | |
| SSP1 | | 0.04 | 0.16 | 0.32 | |
| ADC | PCLK = 12 MHz for CCLK = 12 MHz and 48 MHz; PCLK = 12.5 MHz for CCLK = 100 MHz | 2.12 | 2.09 | 2.07 | |
| CAN | PCLK = CCLK/6 | 0.13 | 0.49 | 1.00 | Average current per CAN |
| CAN0, CAN1, acceptance filter | PCLK = CCLK/6 | 0.22 | 0.85 | 1.73 | Both CAN blocks and acceptance filter ^[1] |
| DMA | PCLK = CCLK | 1.33 | 5.10 | 10.36 | |
| QEI | | 0.05 | 0.20 | 0.41 | |
| GPIO | | 0.33 | 1.27 | 2.58 | |
| I2S | | 0.09 | 0.34 | 0.70 | |
| USB and PLL1 | | 0.94 | 1.32 | 1.94 | |
| Ethernet | Ethernet block enabled in the PCONP register; Ethernet not connected. | 0.49 | 1.87 | 3.79 | |
| Ethernet connected | Ethernet initialized, connected to network, and running web server example. | - | - | 5.19 | |

[1] The combined current of several peripherals running at the same time can be less than the sum of each individual peripheral current measured separately.

11.3 Electrical pin characteristics





12. Dynamic characteristics

12.1 Flash memory

Table 9. Flash characteristics

$T_{amb} = -40\text{ °C to }+85\text{ °C}$, unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|------------|------------------|--|-----------|--------|------|--------|
| N_{endu} | endurance | | [1] 10000 | 100000 | - | cycles |
| t_{ret} | retention time | powered | 10 | - | - | years |
| | | unpowered | 20 | - | - | years |
| t_{er} | erase time | sector or multiple consecutive sectors | 95 | 100 | 105 | ms |
| t_{prog} | programming time | | [2] 0.95 | 1 | 1.05 | ms |

[1] Number of program/erase cycles.

[2] Programming times are given for writing 256 bytes from RAM to the flash. Data must be written to the flash in blocks of 256 bytes.

12.2 External clock

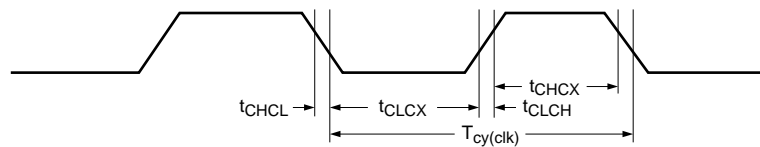
Table 10. Dynamic characteristic: external clock

$T_{amb} = -40\text{ °C to }+85\text{ °C}$; $V_{DD(3V3)}$ over specified ranges. [1]

| Symbol | Parameter | Conditions | Min | Typ ^[2] | Max | Unit |
|---------------|----------------------|------------|--------------------------|--------------------|------|------|
| f_{osc} | oscillator frequency | | 1 | - | 25 | MHz |
| $T_{cy(clk)}$ | clock cycle time | | 40 | - | 1000 | ns |
| t_{CHCX} | clock HIGH time | | $T_{cy(clk)} \times 0.4$ | - | - | ns |
| t_{CLCX} | clock LOW time | | $T_{cy(clk)} \times 0.4$ | - | - | ns |
| t_{CLCH} | clock rise time | | - | - | 5 | ns |
| t_{CHCL} | clock fall time | | - | - | 5 | ns |

[1] Parameters are valid over operating temperature range unless otherwise specified.

[2] Typical ratings are not guaranteed. The values listed are at room temperature (25 °C), nominal supply voltages.



002aaa907

Fig 14. External clock timing (with an amplitude of at least $V_{i(RMS)} = 200\text{ mV}$)

12.3 Internal oscillators

Table 11. Dynamic characteristic: internal oscillators

$T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$; $2.7\text{ V} \leq V_{DD(REG)(3V3)} \leq 3.6\text{ V}$.^[1]

| Symbol | Parameter | Conditions | Min | Typ ^[2] | Max | Unit |
|---------------|----------------------------------|------------|------|--------------------|------|------|
| $f_{osc(RC)}$ | internal RC oscillator frequency | - | 3.96 | 4.02 | 4.04 | MHz |
| $f_{i(RTC)}$ | RTC input frequency | - | - | 32.768 | - | kHz |

[1] Parameters are valid over operating temperature range unless otherwise specified.

[2] Typical ratings are not guaranteed. The values listed are at room temperature (25 °C), nominal supply voltages.

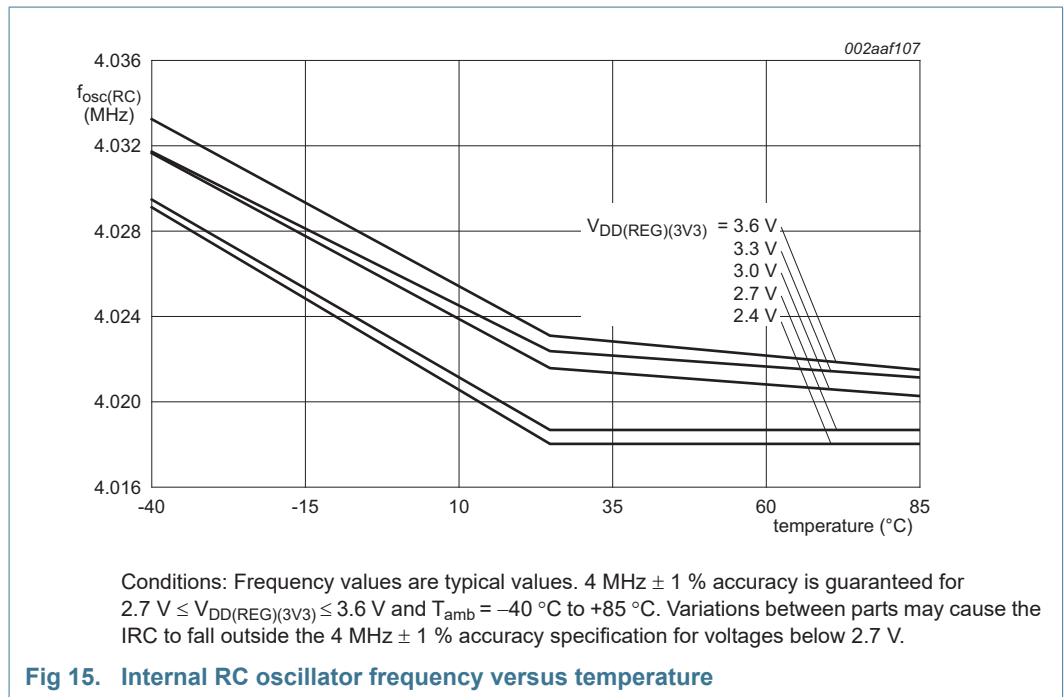


Fig 15. Internal RC oscillator frequency versus temperature

12.4 I/O pins

Table 12. Dynamic characteristic: I/O pins^[1]

$T_{amb} = -40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$; $V_{DD(3V3)}$ over specified ranges.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------|-----------|--------------------------|-----|-----|-----|------|
| t_r | rise time | pin configured as output | 3.0 | - | 5.0 | ns |
| t_f | fall time | pin configured as output | 2.5 | - | 5.0 | ns |

[1] Applies to standard port pins.

12.5 I²C-bus

Table 13. Dynamic characteristic: I²C-bus pins^[1]

$T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$.^[2]

| Symbol | Parameter | | Conditions | Min | Max | Unit |
|---------------------|------------------------------|------------------------------|--|---------------------------|-----|------|
| f _{SCL} | SCL clock frequency | | Standard-mode | 0 | 100 | kHz |
| | | | Fast-mode | 0 | 400 | kHz |
| t _f | fall time | [3][4][5][6] | of both SDA and SCL signals Standard-mode | - | 300 | ns |
| | | | Fast-mode | 20 + 0.1 × C _b | 300 | ns |
| t _{LOW} | LOW period of the SCL clock | | Standard-mode | 4.7 | - | μs |
| | | | Fast-mode | 1.3 | - | μs |
| t _{HIGH} | HIGH period of the SCL clock | | Standard-mode | 4.0 | - | μs |
| | | | Fast-mode | 0.6 | - | μs |
| t _{HD;DAT} | data hold time | [3][7][8] | Standard-mode | 0 | - | μs |
| | | | Fast-mode | 0 | - | μs |
| t _{SU;DAT} | data set-up time | [9] | Standard-mode | 250 | - | ns |
| | | | Fast-mode | 100 | - | ns |

[1] See the I²C-bus specification *UM10204* for details.

[2] Parameters are valid over operating temperature range unless otherwise specified.

[3] A device must internally provide a hold time of at least 300 ns for the SDA signal (with respect to the V_{IH(min)} of the SCL signal) to bridge the undefined region of the falling edge of SCL.

[4] C_b = total capacitance of one bus line in pF.

[5] The maximum t_f for the SDA and SCL bus lines is specified at 300 ns. The maximum fall time for the SDA output stage t_f is specified at 250 ns. This allows series protection resistors to be connected in between the SDA and the SCL pins and the SDA/SCL bus lines without exceeding the maximum specified t_f.

[6] In Fast-mode Plus, fall time is specified the same for both output stage and bus timing. If series resistors are used, designers should allow for this when considering bus timing.

[7] t_{HD;DAT} is the data hold time that is measured from the falling edge of SCL; applies to data in transmission and the acknowledge.

[8] The maximum t_{HD;DAT} could be 3.45 μs and 0.9 μs for Standard-mode and Fast-mode but must be less than the maximum of t_{VD;DAT} or t_{VD;ACK} by a transition time (see the I²C-bus specification *UM10204*). This maximum must only be met if the device does not stretch the LOW period (t_{LOW}) of the SCL signal. If the clock stretches the SCL, the data must be valid by the set-up time before it releases the clock.

[9] t_{SU;DAT} is the data set-up time that is measured with respect to the rising edge of SCL; applies to data in transmission and the acknowledge.

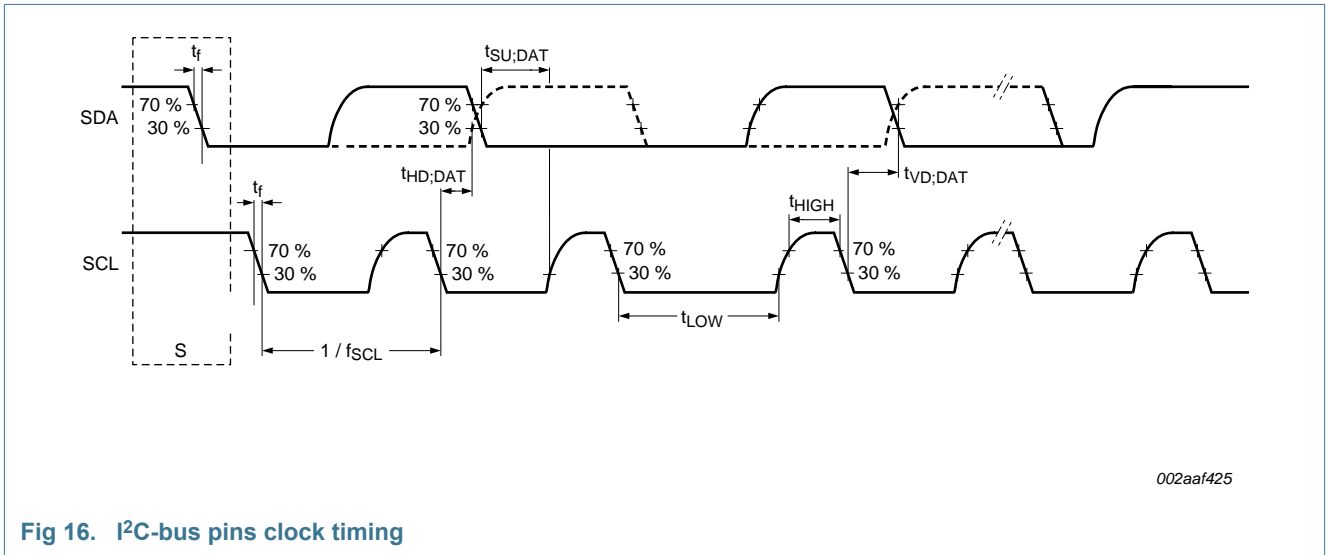


Fig 16. I²C-bus pins clock timing

12.6 I²S-bus interface (LPC1759/58/56 only)

Table 14. Dynamic characteristics: I²S-bus interface pins

T_{amb} = -40 °C to +85 °C.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-----------------------------------|------------------------|---------------------------------|-----|------------------------------|------------------------------|------|
| common to input and output | | | | | | |
| t _r | rise time | | [1] | - | 35 | ns |
| t _f | fall time | | [1] | - | 35 | ns |
| t _{WH} | pulse width HIGH | on pins I2STX_CLK and I2SRX_CLK | [1] | 0.495 × T _{cy(clk)} | - | - |
| t _{WL} | pulse width LOW | on pins I2STX_CLK and I2SRX_CLK | [1] | - | 0.505 × T _{cy(clk)} | ns |
| output | | | | | | |
| t _{v(Q)} | data output valid time | on pin I2STX_SDA; | [1] | - | 30 | ns |
| | | on pin I2STX_WS | [1] | - | 30 | ns |
| input | | | | | | |
| t _{su(D)} | data input set-up time | on pin I2SRX_SDA | [1] | 3.5 | - | ns |
| t _{h(D)} | data input hold time | on pin I2SRX_SDA | [1] | 4.0 | - | ns |

[1] CCLK = 20 MHz; peripheral clock to the I²S-bus interface PCLK = CCLK/4; T_{cy(clk)} = 1600 ns, corresponds to the SCK signal in the I²S-bus specification.

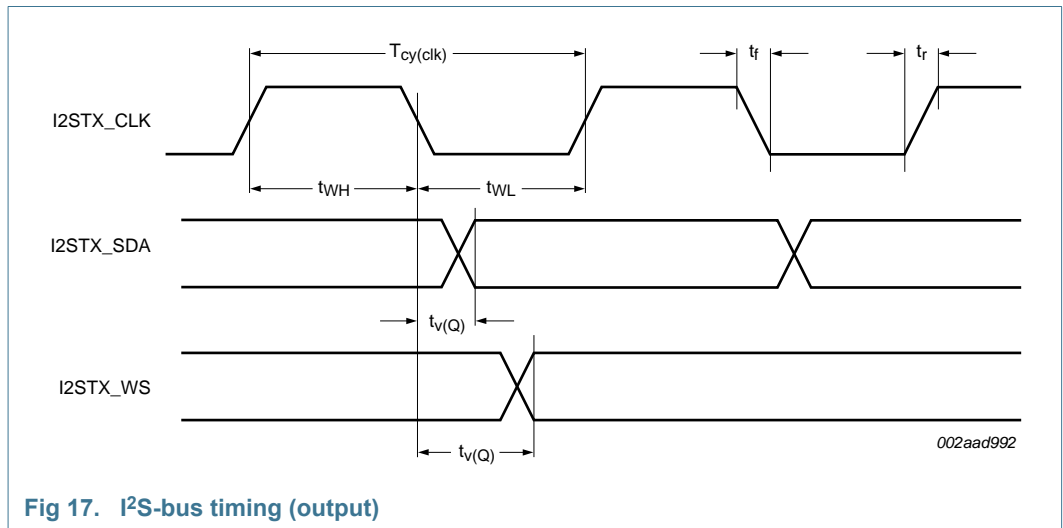


Fig 17. I²S-bus timing (output)

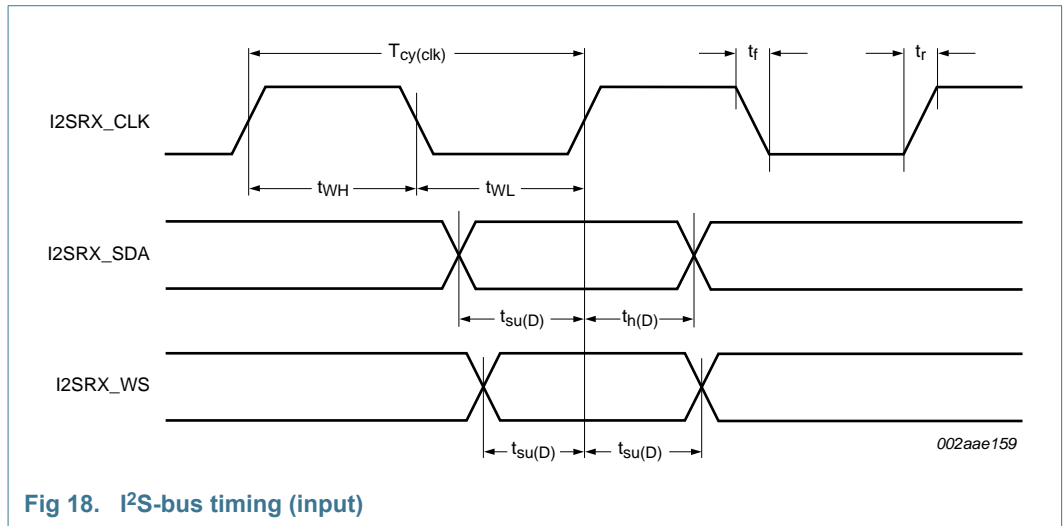


Fig 18. I²S-bus timing (input)

12.7 SSP interface

The maximum SSP speed is 33 Mbit/s in master mode or 8 Mbit/s in slave mode. In slave mode, the maximum SSP clock rate must be 1/12 of the SSP PCLK clock rate.

Table 15. Dynamic characteristics: SSP pins in SPI mode

$C_L = 30\text{ pF}$ on all SSP pins; $T_{amb} = -40\text{ }^\circ\text{C}$ to $85\text{ }^\circ\text{C}$; $V_{DD(3V3)} = 3.3\text{ V}$ to 3.6 V ; input slew = 1 ns ; sampled at 10 % and 90 % of the signal level. Values guaranteed by design.

| Symbol | Parameter | Conditions | Min | Max | Unit |
|-------------------|------------------------|-------------|------|------------------------------|------|
| SSP master | | | | | |
| t_{DS} | data set-up time | in SPI mode | 16.1 | - | ns |
| t_{DH} | data hold time | in SPI mode | 0 | - | ns |
| $t_{v(Q)}$ | data output valid time | in SPI mode | - | 2.5 | ns |
| $t_{h(Q)}$ | data output hold time | in SPI mode | 0 | - | ns |
| SSP slave | | | | | |
| t_{DS} | data set-up time | in SPI mode | 16.1 | - | ns |
| t_{DH} | data hold time | in SPI mode | 0 | - | ns |
| $t_{v(Q)}$ | data output valid time | in SPI mode | - | $3 \cdot T_{cy(PCLK)} + 2.5$ | ns |
| $t_{h(Q)}$ | data output hold time | in SPI mode | 0 | - | ns |

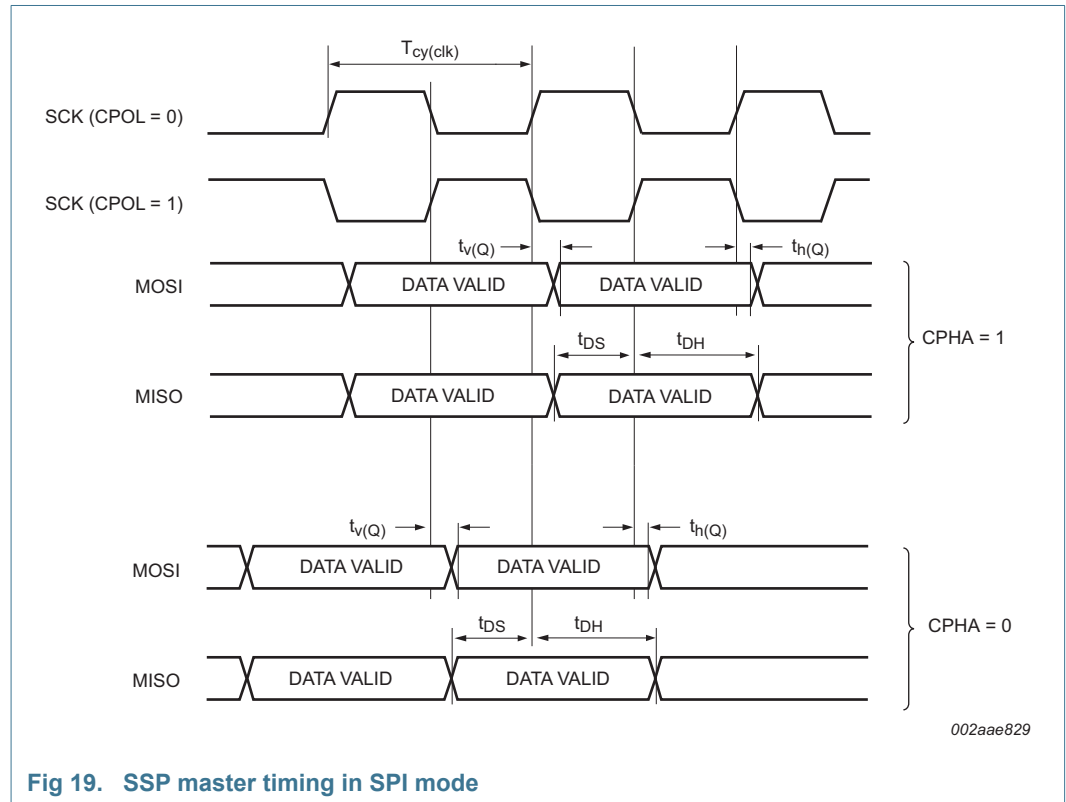


Fig 19. SSP master timing in SPI mode

002aae829

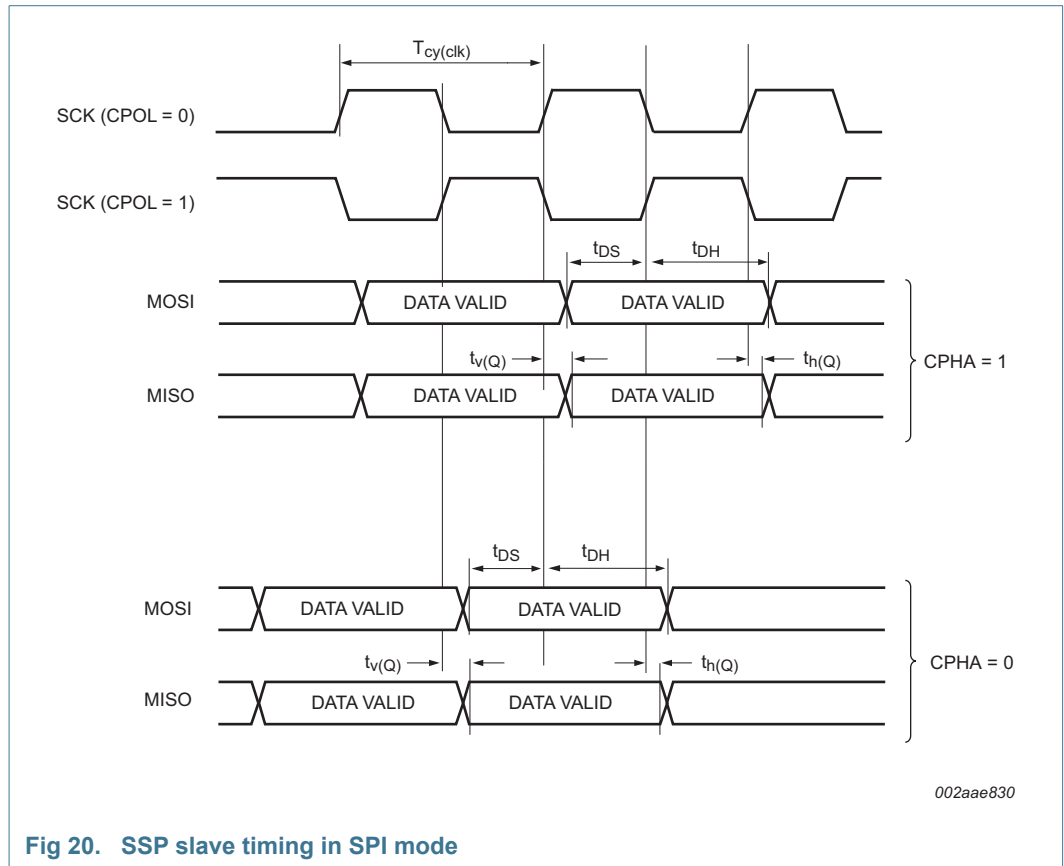


Fig 20. SSP slave timing in SPI mode

12.8 USB interface

Table 16. Dynamic characteristics: USB pins (full-speed)

$C_L = 50\text{ pF}$; $R_{pu} = 1.5\text{ k}\Omega$ on D+ to $V_{DD(3V3)}$; $3.0\text{ V} \leq V_{DD(3V3)} \leq 3.6\text{ V}$.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------|---|-----------------------------------|--------|-----|-------|------|
| t_r | rise time | 10 % to 90 % | 8.5 | - | 13.8 | ns |
| t_f | fall time | 10 % to 90 % | 7.7 | - | 13.7 | ns |
| t_{FRFM} | differential rise and fall time matching | t_r / t_f | - | - | 109 | % |
| V_{CRS} | output signal crossover voltage | | 1.3 | - | 2.0 | V |
| t_{FEOPT} | source SE0 interval of EOP | see Figure 21 | 160 | - | 175 | ns |
| t_{FDEOP} | source jitter for differential transition to SE0 transition | see Figure 21 | -2 | - | +5 | ns |
| t_{JR1} | receiver jitter to next transition | | -18.5 | - | +18.5 | ns |
| t_{JR2} | receiver jitter for paired transitions | 10 % to 90 % | -9 | - | +9 | ns |
| t_{EOPR1} | EOP width at receiver | must reject as EOP; see Figure 21 | [1] 40 | - | - | ns |
| t_{EOPR2} | EOP width at receiver | must accept as EOP; see Figure 21 | [1] 82 | - | - | ns |

[1] Characterized but not implemented as production test. Guaranteed by design.

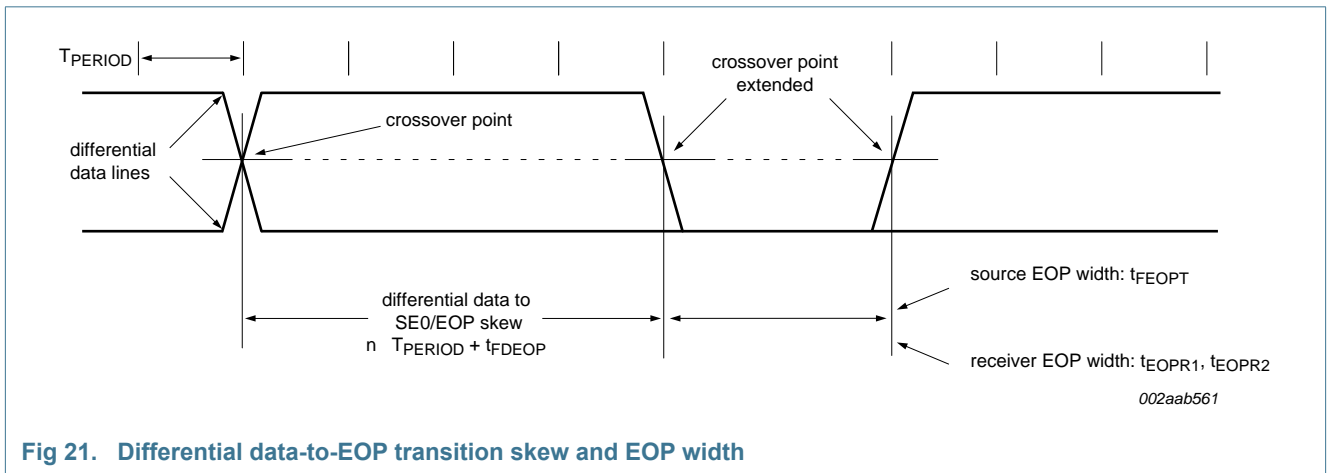


Fig 21. Differential data-to-EOP transition skew and EOP width

12.9 SPI

Table 17. Dynamic characteristics of SPI pins

$T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$.

| Symbol | Parameter | | Min | Typ | Max | Unit |
|-------------------|----------------------------|-----|------------------------------|-----|---------------------------|------|
| $T_{cy(PCLK)}$ | PCLK cycle time | | 10 | - | - | ns |
| T_{SPICYC} | SPI cycle time | [1] | 79.6 | - | - | ns |
| $t_{SPICLKH}$ | SPICLK HIGH time | | $0.485 \times T_{SPICYC}$ | - | - | ns |
| $t_{SPICLKL}$ | SPICLK LOW time | | | - | $0.515 \times T_{SPICYC}$ | ns |
| SPI master | | | | | | |
| t_{SPIDSU} | SPI data set-up time | [2] | 0 | - | - | ns |
| t_{SPIDH} | SPI data hold time | [2] | $2 \times T_{cy(PCLK)} - 5$ | - | - | ns |
| t_{SPIQV} | SPI data output valid time | [2] | $2 \times T_{cy(PCLK)} + 30$ | - | - | ns |
| t_{SPIOH} | SPI output data hold time | [2] | $2 \times T_{cy(PCLK)} + 5$ | - | - | ns |
| SPI slave | | | | | | |
| t_{SPIDSU} | SPI data set-up time | [2] | 0 | - | - | ns |
| t_{SPIDH} | SPI data hold time | [2] | $2 \times T_{cy(PCLK)} + 5$ | - | - | ns |
| t_{SPIQV} | SPI data output valid time | [2] | $2 \times T_{cy(PCLK)} + 35$ | - | - | ns |
| t_{SPIOH} | SPI output data hold time | [2] | $2 \times T_{cy(PCLK)} + 15$ | - | - | ns |

[1] $T_{SPICYC} = (T_{cy(PCLK)} \times n) \pm 0.5\%$, n is the SPI clock divider value ($n \geq 8$); PCLK is derived from the processor clock CCLK.

[2] Timing parameters are measured with respect to the 50 % edge of the clock PCLK and the 10 % (90 %) edge of the data signal (MOSI or MISO).

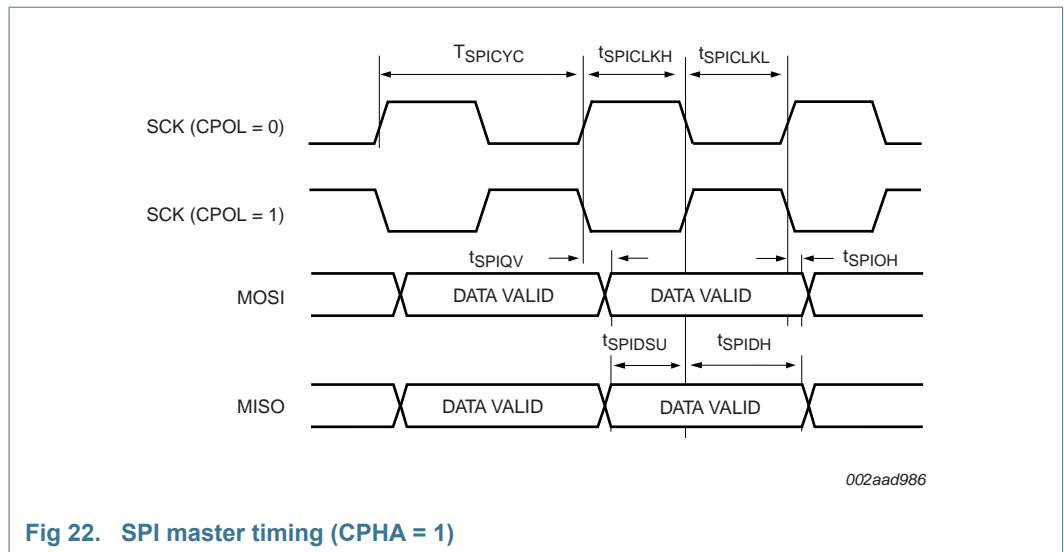


Fig 22. SPI master timing (CPHA = 1)

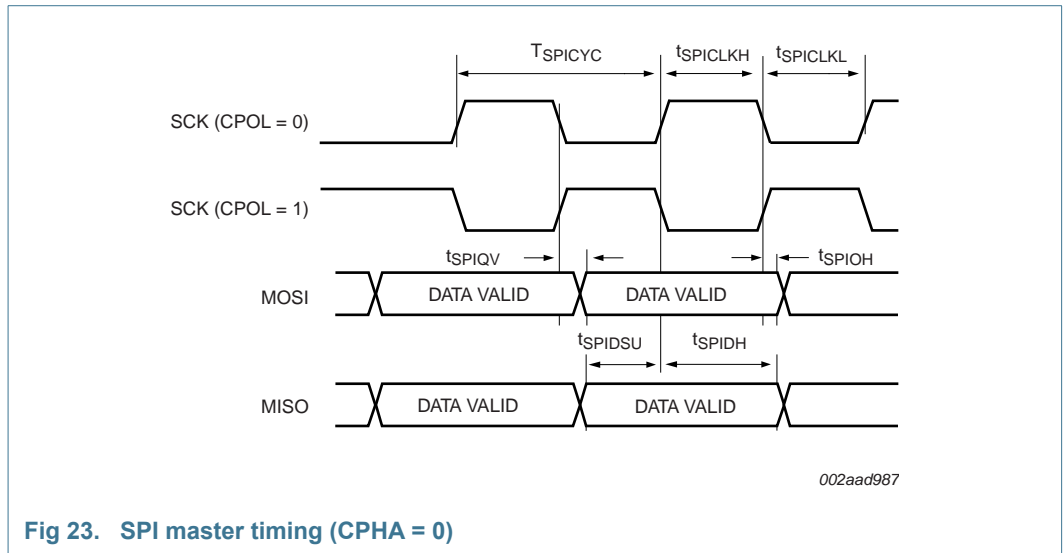


Fig 23. SPI master timing (CPHA = 0)

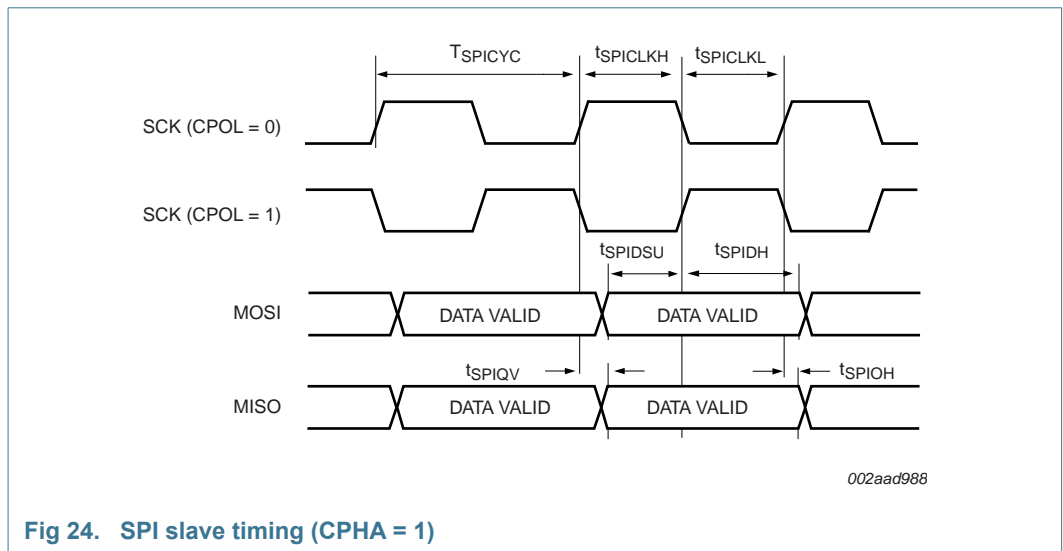


Fig 24. SPI slave timing (CPHA = 1)

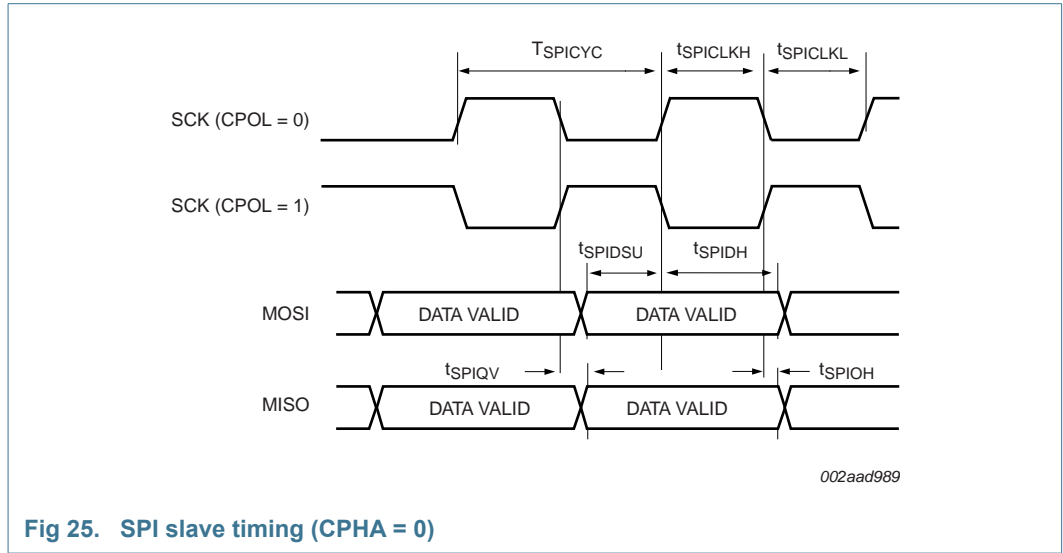


Fig 25. SPI slave timing (CPHA = 0)

13. ADC electrical characteristics

Table 18. ADC characteristics (full resolution)

$V_{DDA} = 2.5\text{ V to }3.6\text{ V}$; $T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$ unless otherwise specified; ADC frequency 13 MHz; 12-bit resolution.^[1]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|----------------|-------------------------------------|------------|--------|-----|-----------|------------|
| V_{IA} | analog input voltage | | 0 | - | V_{DDA} | V |
| C_{ia} | analog input capacitance | | - | - | 15 | pF |
| E_D | differential linearity error | | [2][3] | - | ± 1 | LSB |
| $E_{L(adj)}$ | integral non-linearity | | [4] | - | ± 3 | LSB |
| E_O | offset error | | [5][6] | - | ± 2 | LSB |
| E_G | gain error | | [7] | - | 0.5 | % |
| E_T | absolute error | | [8] | - | 4 | LSB |
| R_{vsi} | voltage source interface resistance | | [9] | - | 7.5 | k Ω |
| $f_{clk(ADC)}$ | ADC clock frequency | | - | - | 13 | MHz |
| $f_c(ADC)$ | ADC conversion frequency | | [10] | - | 200 | kHz |

- [1] V_{DDA} and VREFP should be tied to $V_{DD(3V3)}$ if the ADC and DAC are not used.
- [2] The ADC is monotonic, there are no missing codes.
- [3] The differential linearity error (E_D) is the difference between the actual step width and the ideal step width. See [Figure 26](#).
- [4] The integral non-linearity ($E_{L(adj)}$) is the peak difference between the center of the steps of the actual and the ideal transfer curve after appropriate adjustment of gain and offset errors. See [Figure 26](#).
- [5] The offset error (E_O) is the absolute difference between the straight line which fits the actual curve and the straight line which fits the ideal curve. See [Figure 26](#).
- [6] ADCOFFS value (bits 7:4) = 2 in the ADTRM register. See LPC17xx user manual UM10360.
- [7] The gain error (E_G) is the relative difference in percent between the straight line fitting the actual transfer curve after removing offset error, and the straight line which fits the ideal transfer curve. See [Figure 26](#).
- [8] The absolute error (E_T) is the maximum difference between the center of the steps of the actual transfer curve of the non-calibrated ADC and the ideal transfer curve. See [Figure 26](#).
- [9] See [Figure 27](#).
- [10] The conversion frequency corresponds to the number of samples per second.

Table 19. ADC characteristics (lower resolution)*T_{amb} = -40 °C to +85 °C unless otherwise specified; 12-bit ADC used as 10-bit resolution ADC.*^[1]

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|-----------------------|------------------------------|----------------------------------|--------|-----|------|-----|------|
| E _D | differential linearity error | | [2][3] | - | ±1 | - | LSB |
| E _{L(adj)} | integral non-linearity | | [4] | - | ±1.5 | - | LSB |
| E _O | offset error | | [5] | - | ±2 | - | LSB |
| E _G | gain error | | [6] | - | ±2 | - | LSB |
| f _{clk(ADC)} | ADC clock frequency | 3.0 V ≤ V _{DDA} ≤ 3.6 V | | - | - | 33 | MHz |
| | | 2.7 V ≤ V _{DDA} < 3.0 V | | - | - | 25 | MHz |
| f _{c(ADC)} | ADC conversion frequency | 3 V ≤ V _{DDA} ≤ 3.6 V | [7] | - | - | 500 | kHz |
| | | 2.7 V ≤ V _{DDA} < 3.0 V | [7] | - | - | 400 | kHz |

[1] V_{DDA} and VREFP should be tied to V_{DD(3V3)} if the ADC and DAC are not used.

[2] The ADC is monotonic, there are no missing codes.

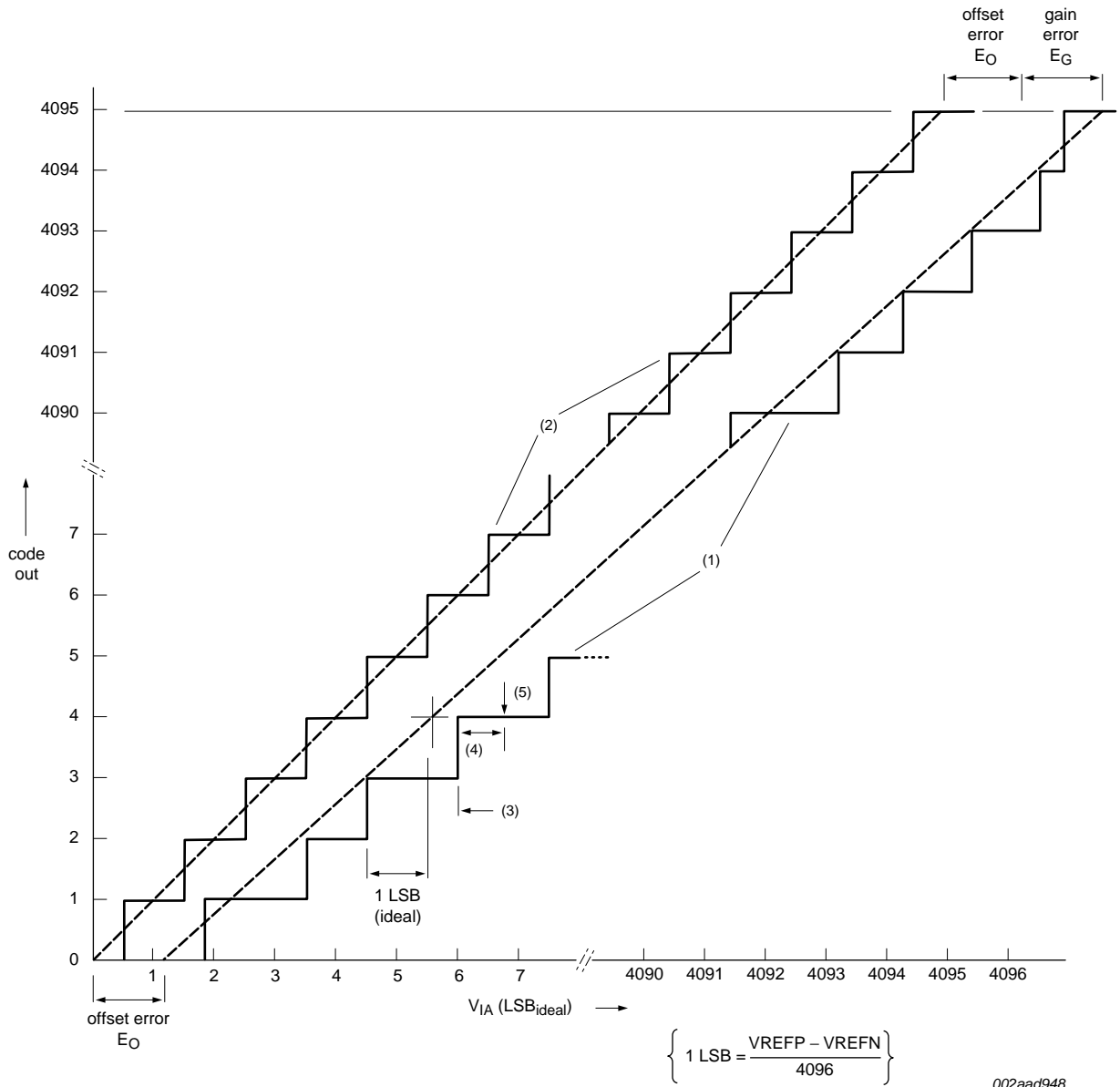
[3] The differential linearity error (E_D) is the difference between the actual step width and the ideal step width. See [Figure 26](#).

[4] The integral non-linearity (E_{L(adj)}) is the peak difference between the center of the steps of the actual and the ideal transfer curve after appropriate adjustment of gain and offset errors. See [Figure 26](#).

[5] The offset error (E_O) is the absolute difference between the straight line which fits the actual curve and the straight line which fits the ideal curve. See [Figure 26](#).

[6] The gain error (E_G) is the relative difference in percent between the straight line fitting the actual transfer curve after removing offset error, and the straight line which fits the ideal transfer curve. See [Figure 26](#).

[7] The conversion frequency corresponds to the number of samples per second.



- (1) Example of an actual transfer curve.
- (2) The ideal transfer curve.
- (3) Differential linearity error (E_D).
- (4) Integral non-linearity ($E_{L(adj)}$).
- (5) Center of a step of the actual transfer curve.

Fig 26. 12-bit ADC characteristics

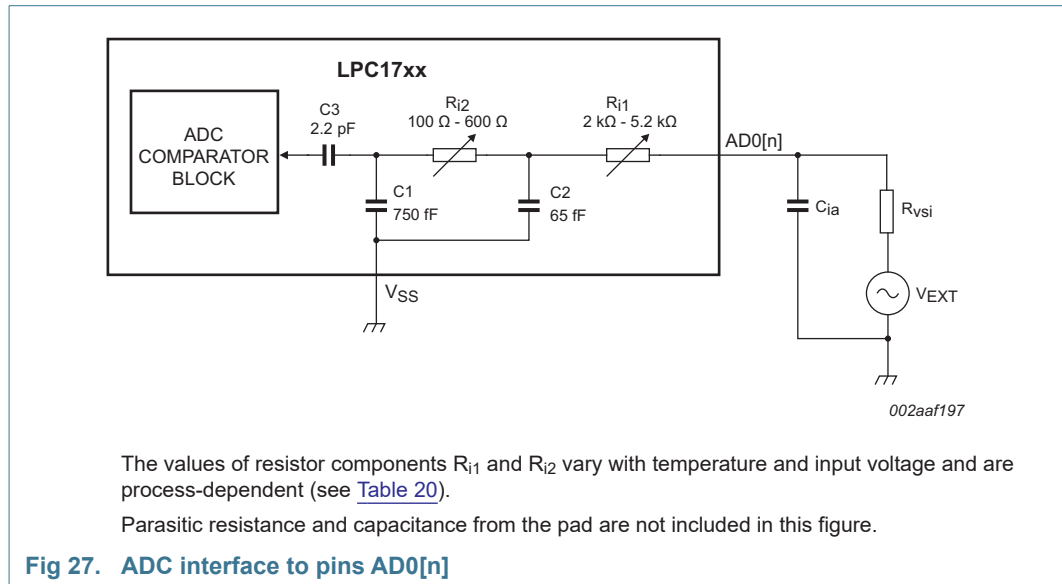


Table 20. ADC interface components

| Component | Range | Description |
|-----------|----------------|--|
| R_{i1} | 2 kΩ to 5.2 kΩ | Switch-on resistance for channel selection switch. Varies with temperature, input voltage, and process. |
| R_{i2} | 100 Ω to 600 Ω | Switch-on resistance for the comparator input switch. Varies with temperature, input voltage, and process. |
| C1 | 750 fF | Parasitic capacitance from the ADC block level. |
| C2 | 65 fF | Parasitic capacitance from the ADC block level. |
| C3 | 2.2 pF | Sampling capacitor. |

14. DAC electrical characteristics (LPC1759/58/56/54 only)

Table 21. DAC electrical characteristics

$V_{DDA} = 2.7\text{ V to }3.6\text{ V}$; $T_{amb} = -40\text{ °C to }+85\text{ °C}$ unless otherwise specified

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------------|------------------------------|------------|-----|------|-----|------|
| E_D | differential linearity error | | - | ±1 | - | LSB |
| $E_{L(adj)}$ | integral non-linearity | | - | ±1.5 | - | LSB |
| E_O | offset error | | - | 0.6 | - | % |
| E_G | gain error | | - | 0.6 | - | % |
| C_L | load capacitance | | - | 200 | - | pF |
| R_L | load resistance | | 1 | - | - | kΩ |

15. Application information

15.1 Suggested USB interface solutions

If the LPC1759/58/56/54/52/51 V_{DD} is always greater than 0 V while $V_{BUS} = 5$ V, the V_{BUS} pin can be connected directly to the V_{BUS} pin on the USB connector.

This applies to bus powered devices where the USB cable supplies the system power. For systems where V_{DD} can be 0 V and V_{BUS} is directly applied to the V_{BUS} pin, precautions must be taken to reduce the voltage to below 3.6 V.

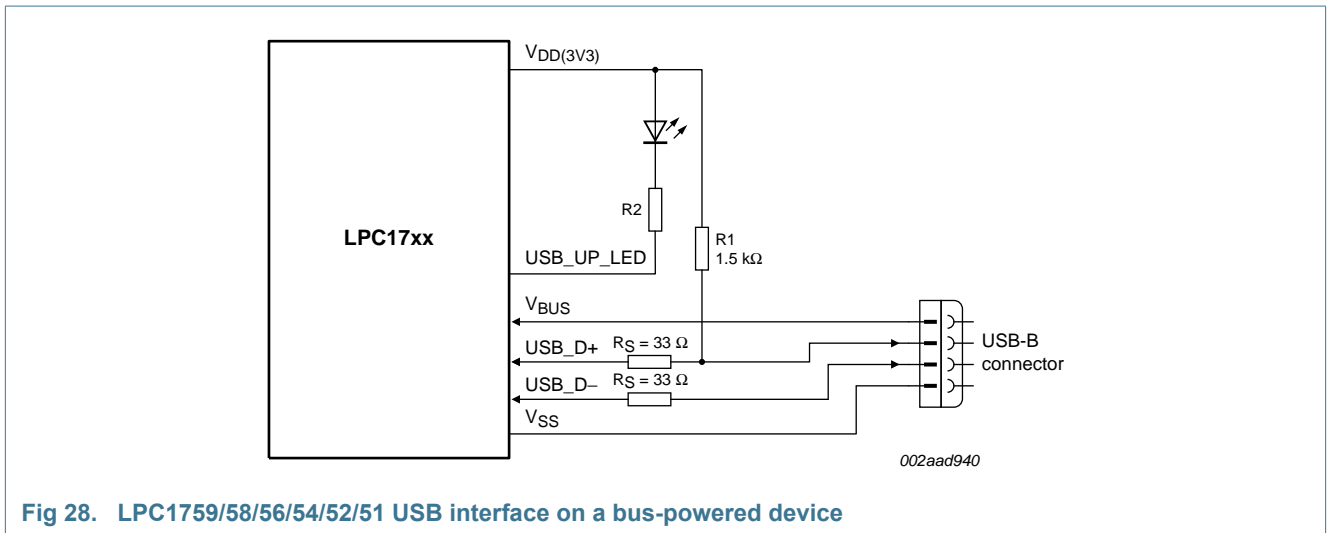


Fig 28. LPC1759/58/56/54/52/51 USB interface on a bus-powered device

The maximum allowable voltage on the V_{BUS} pin is 3.6 V. One method is to use a voltage divider to connect the V_{BUS} pin to the V_{BUS} on the USB connector.

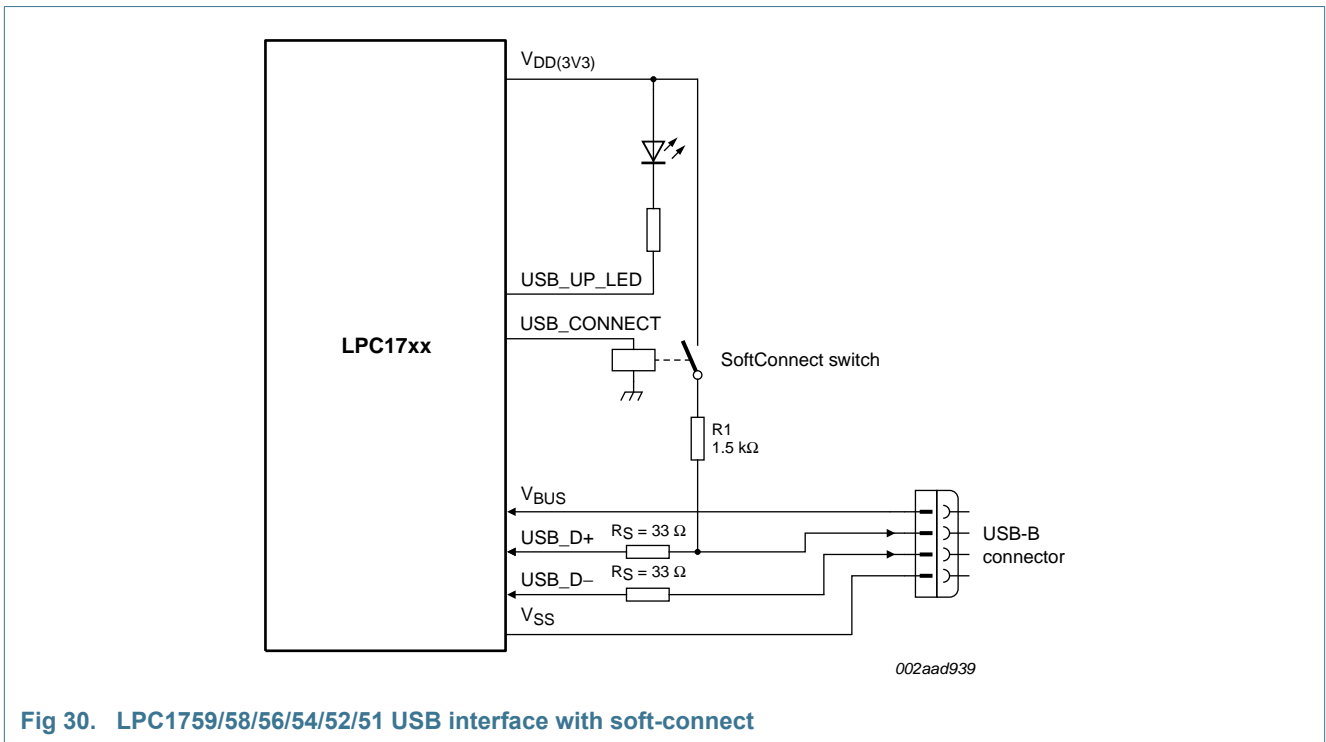
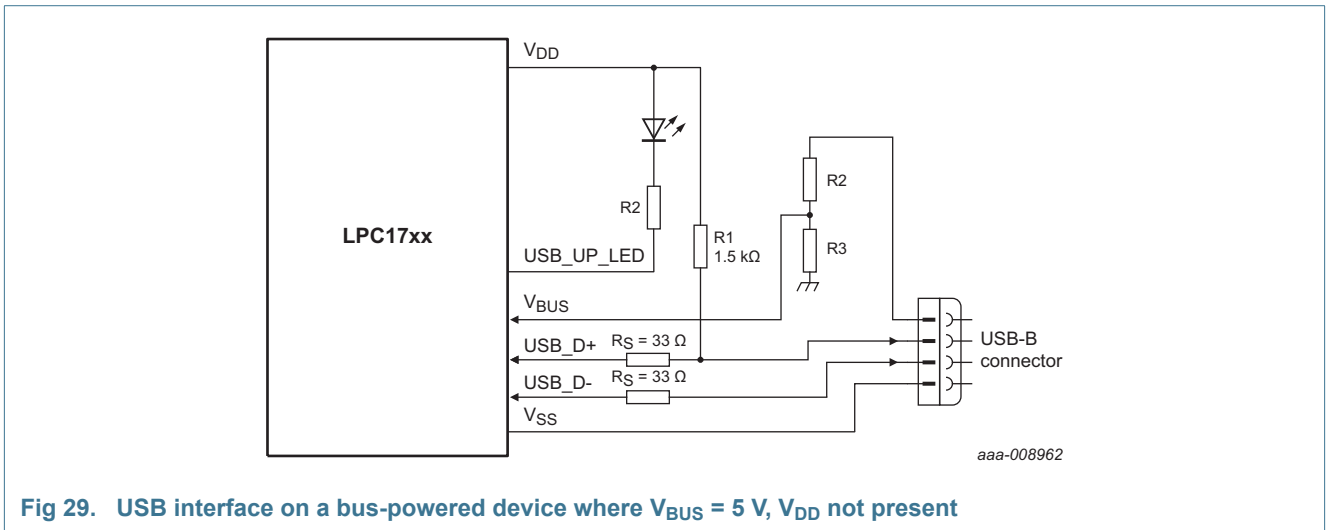
The voltage divider ratio should be such that the V_{BUS} pin will be greater than $0.7V_{DD}$ to indicate a logic HIGH while below the 3.6 V allowable maximum voltage.

Use the following operating conditions:

$$V_{BUS_{max}} = 5.25 \text{ V}$$

$$V_{DD} = 3.6 \text{ V}$$

The voltage divider would need to provide a reduction of $3.6 \text{ V}/5.25 \text{ V}$ or $\sim 0.686 \text{ V}$.



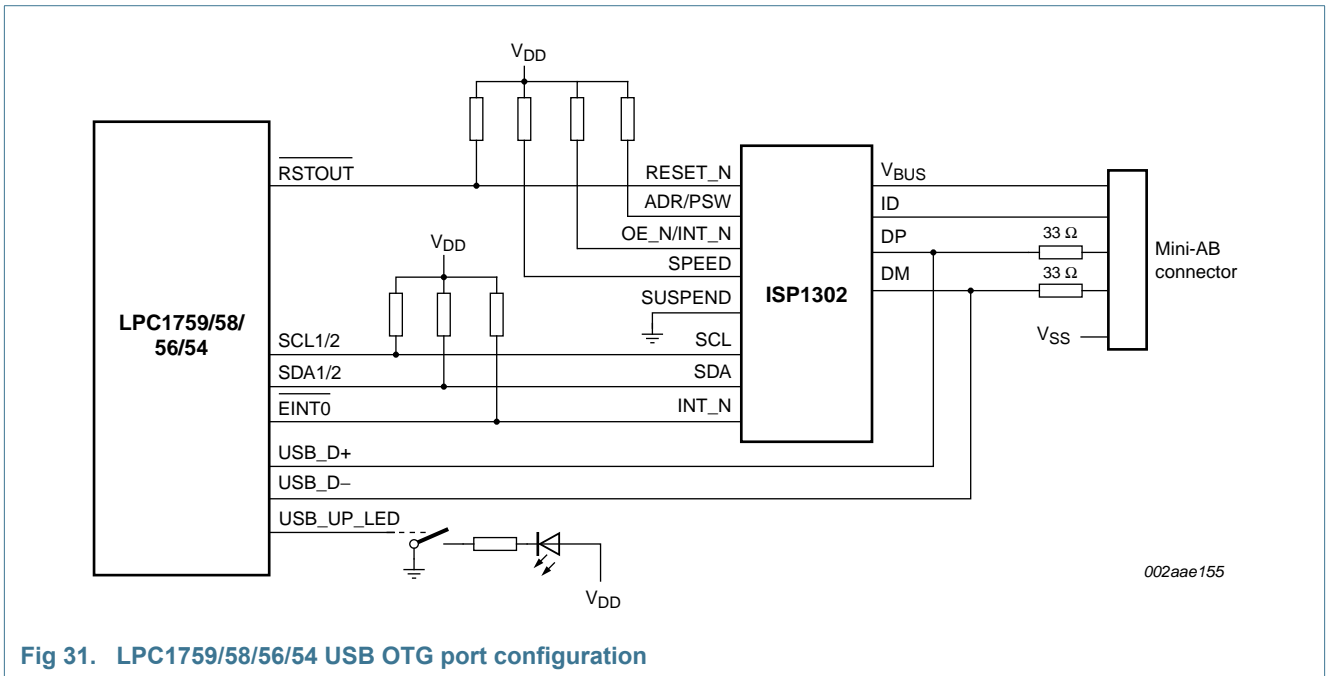


Fig 31. LPC1759/58/56/54 USB OTG port configuration

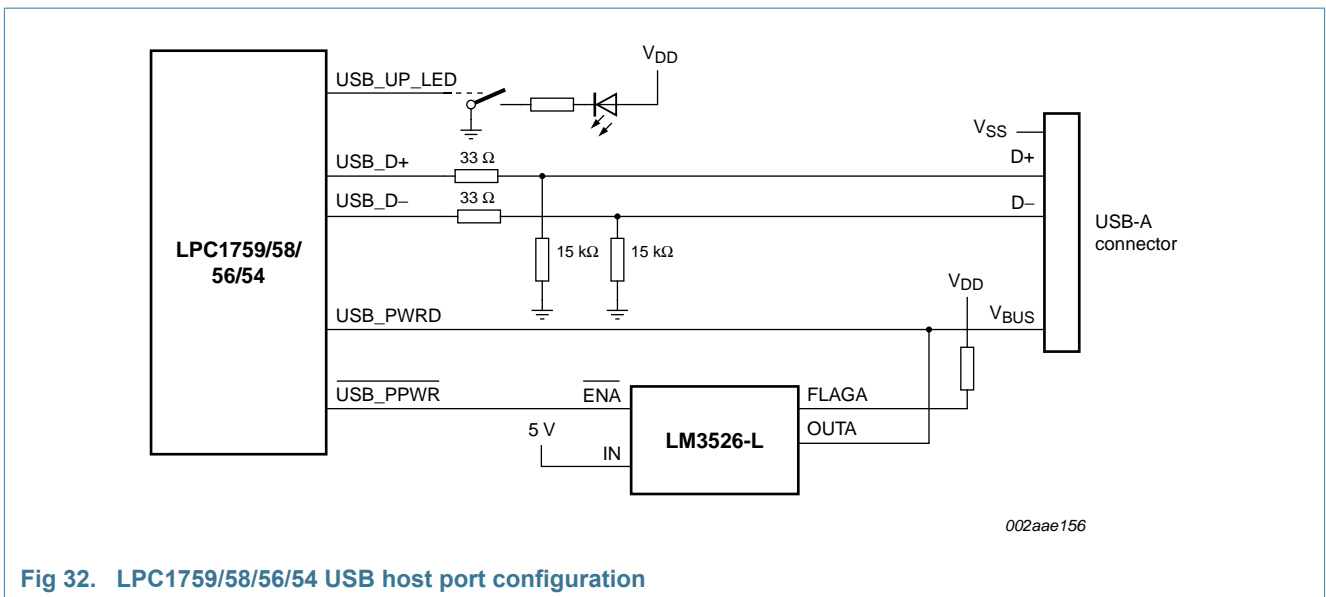


Fig 32. LPC1759/58/56/54 USB host port configuration

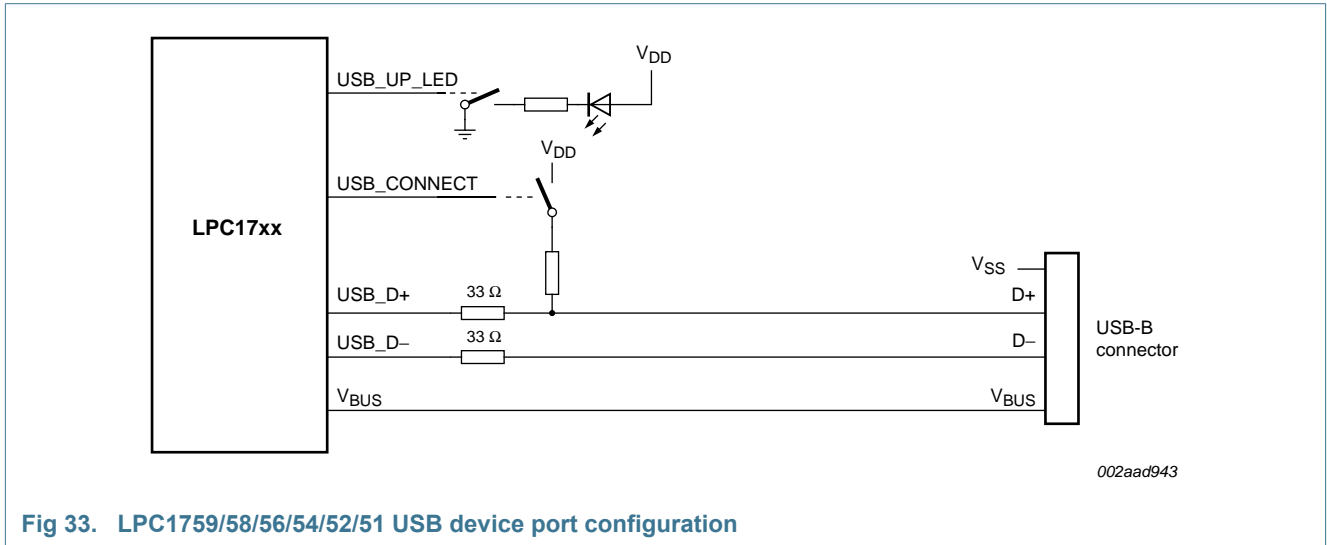


Fig 33. LPC1759/58/56/54/52/51 USB device port configuration

15.2 Crystal oscillator XTAL input and component selection

The input voltage to the on-chip oscillators is limited to 1.8 V. If the oscillator is driven by a clock in slave mode, it is recommended that the input be coupled through a capacitor with $C_i = 100$ pF. To limit the input voltage to the specified range, choose an additional capacitor to ground C_g which attenuates the input voltage by a factor $C_i / (C_i + C_g)$. In slave mode, a minimum of 200 mV(RMS) is needed.

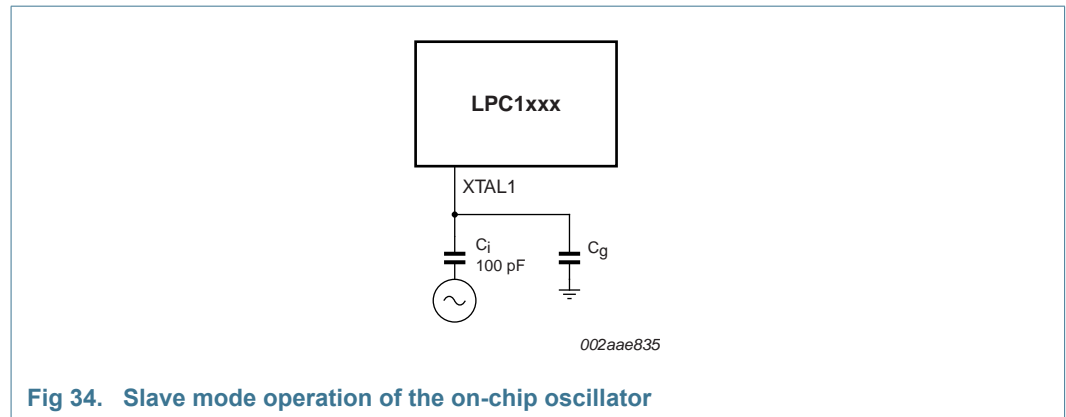


Fig 34. Slave mode operation of the on-chip oscillator

In slave mode the input clock signal should be coupled by means of a capacitor of 100 pF (Figure 34), with an amplitude between 200 mV(RMS) and 1000 mV(RMS). This corresponds to a square wave signal with a signal swing of between 280 mV and 1.4 V. The XTALOUT pin in this configuration can be left unconnected.

External components and models used in oscillation mode are shown in Figure 35 and in Table 22 and Table 23. Since the feedback resistance is integrated on chip, only a crystal and the capacitances C_{X1} and C_{X2} need to be connected externally in case of fundamental mode oscillation (the fundamental frequency is represented by L, C_L and R_S). Capacitance C_P in Figure 35 represents the parallel package capacitance and should not be larger than 7 pF. Parameters F_{OSC} , C_L , R_S and C_P are supplied by the crystal manufacturer.

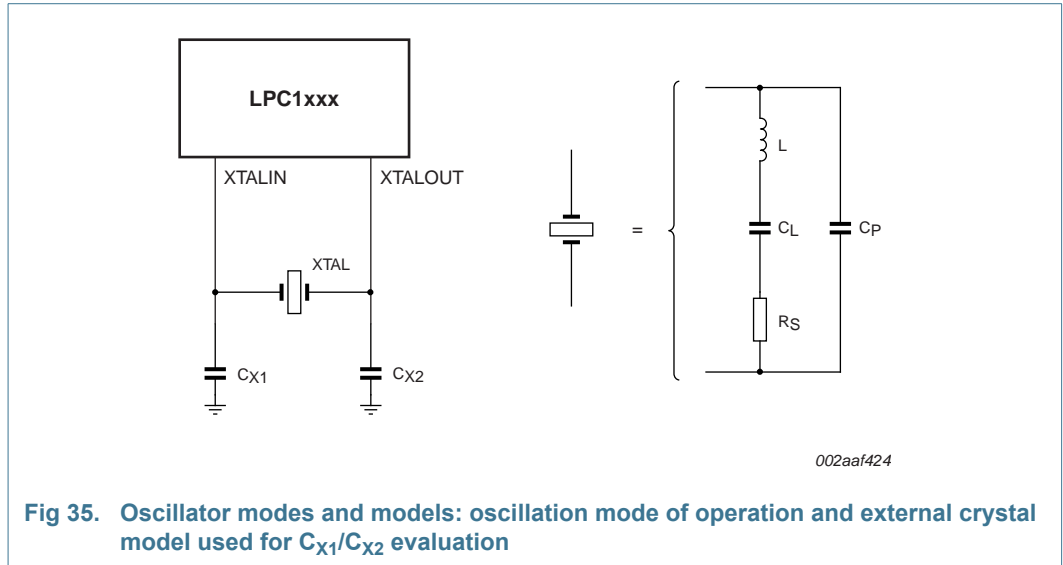


Table 22. Recommended values for C_{X1}/C_{X2} in oscillation mode (crystal and external components parameters): low frequency mode

| Fundamental oscillation frequency F_{Osc} | Crystal load capacitance C_L | Maximum crystal series resistance R_S | External load capacitors C_{X1}/C_{X2} |
|---|--------------------------------|---|--|
| 1 MHz to 5 MHz | 10 pF | < 300 Ω | 18 pF, 18 pF |
| | 20 pF | < 300 Ω | 39 pF, 39 pF |
| | 30 pF | < 300 Ω | 57 pF, 57 pF |
| 5 MHz to 10 MHz | 10 pF | < 300 Ω | 18 pF, 18 pF |
| | 20 pF | < 200 Ω | 39 pF, 39 pF |
| | 30 pF | < 100 Ω | 57 pF, 57 pF |
| 10 MHz to 15 MHz | 10 pF | < 160 Ω | 18 pF, 18 pF |
| | 20 pF | < 60 Ω | 39 pF, 39 pF |
| 15 MHz to 20 MHz | 10 pF | < 80 Ω | 18 pF, 18 pF |

Table 23. Recommended values for C_{X1}/C_{X2} in oscillation mode (crystal and external components parameters): high frequency mode

| Fundamental oscillation frequency F_{Osc} | Crystal load capacitance C_L | Maximum crystal series resistance R_S | External load capacitors C_{X1}, C_{X2} |
|---|--------------------------------|---|---|
| 15 MHz to 20 MHz | 10 pF | < 180 Ω | 18 pF, 18 pF |
| | 20 pF | < 100 Ω | 39 pF, 39 pF |
| 20 MHz to 25 MHz | 10 pF | < 160 Ω | 18 pF, 18 pF |
| | 20 pF | < 80 Ω | 39 pF, 39 pF |

15.3 XTAL Printed-Circuit Board (PCB) layout guidelines

The crystal should be connected on the PCB as close as possible to the oscillator input and output pins of the chip. Take care that the load capacitors C_{X1} , C_{X2} , and C_{X3} in case of third overtone crystal usage have a common ground plane. The external components must also be connected to the ground plain. Loops must be made as small as possible in

order to keep the noise coupled in via the PCB as small as possible. Also parasitics should stay as small as possible. Values of C_{x1} and C_{x2} should be chosen smaller according to the increase in parasitics of the PCB layout.

15.4 Standard I/O pin configuration

Figure 36 shows the possible pin modes for standard I/O pins with analog input function:

- Digital output driver: Open-drain mode enabled/disabled
- Digital input: Pull-up enabled/disabled
- Digital input: Pull-down enabled/disabled
- Digital input: Repeater mode enabled/disabled
- Analog input

The default configuration for standard I/O pins is input with pull-up enabled. The weak MOS devices provide a drive capability equivalent to pull-up and pull-down resistors.

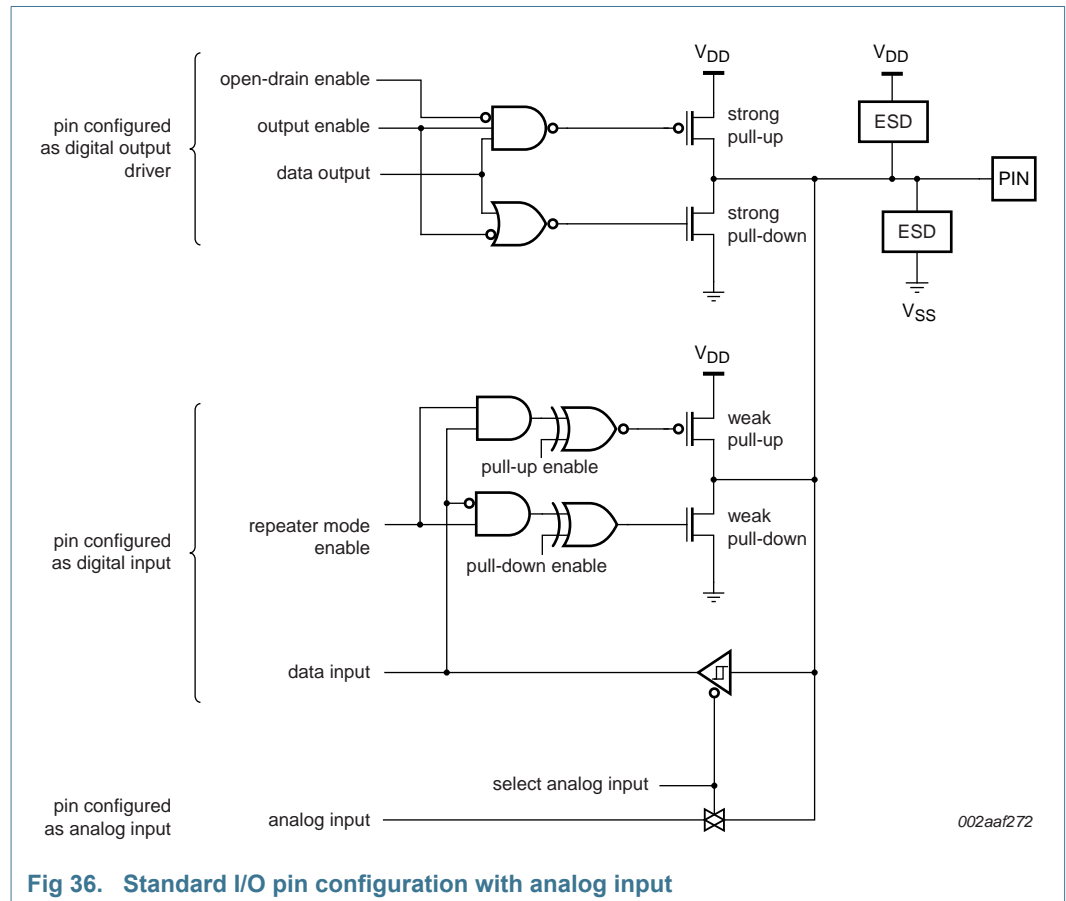


Fig 36. Standard I/O pin configuration with analog input

15.5 Reset pin configuration

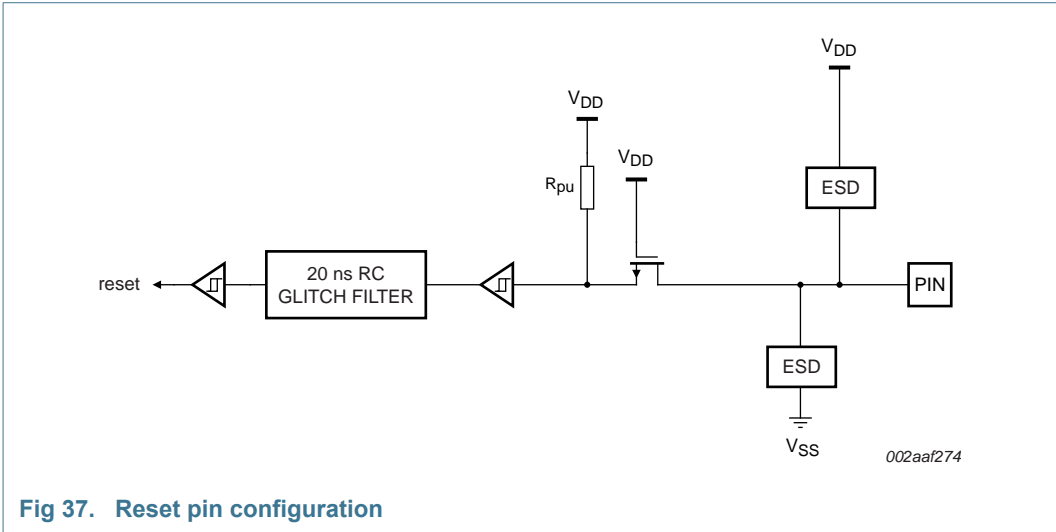


Fig 37. Reset pin configuration

15.6 ElectroMagnetic Compatibility (EMC)

Radiated emission measurements according to the IEC61967-2 standard using the TEM-cell method are shown for part LPC1768.

Table 24. ElectroMagnetic Compatibility (EMC) for part LPC1768 (TEM-cell method)

$V_{DD} = 3.3\text{ V}$; $T_{amb} = 25\text{ °C}$.

| Parameter | Frequency band | System clock = | | | | | Unit |
|---|-------------------|----------------|--------|--------|--------|---------|------------|
| | | 12 MHz | 24 MHz | 48 MHz | 72 MHz | 100 MHz | |
| Input clock: IRC (4 MHz) | | | | | | | |
| maximum peak level | 150 kHz to 30 MHz | -7 | -6 | -4 | -7 | -7 | dB μ V |
| | 30 MHz to 150 MHz | +1 | +5 | +11 | +16 | +9 | dB μ V |
| | 150 MHz to 1 GHz | -2 | +4 | +11 | +12 | +19 | dB μ V |
| IEC level ^[1] | - | O | O | N | M | L | - |
| Input clock: crystal oscillator (12 MHz) | | | | | | | |
| maximum peak level | 150 kHz to 30 MHz | -5 | -4 | -4 | -7 | -8 | dB μ V |
| | 30 MHz to 150 MHz | -1 | +5 | +10 | +15 | +7 | dB μ V |
| | 150 MHz to 1 GHz | -1 | +6 | +11 | +10 | +16 | dB μ V |
| IEC level ^[1] | - | O | O | N | M | M | - |

[1] IEC levels refer to Appendix D in the IEC61967-2 Specification.

16. Package outline

LQFP80: plastic low profile quad flat package; 80 leads; body 12 x 12 x 1.4 mm

SOT315-1

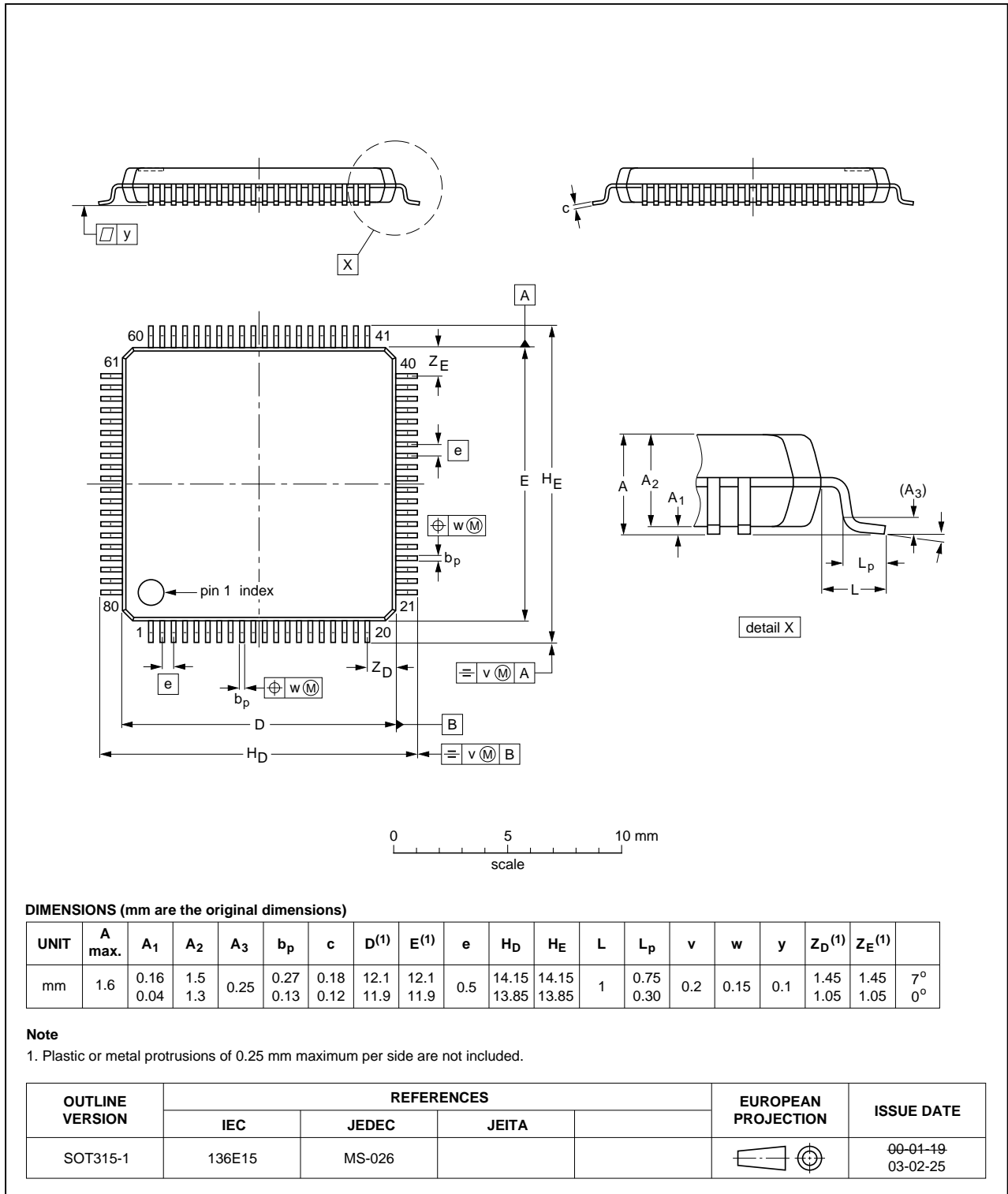


Fig 38. Package outline (LQFP80)

17. Soldering

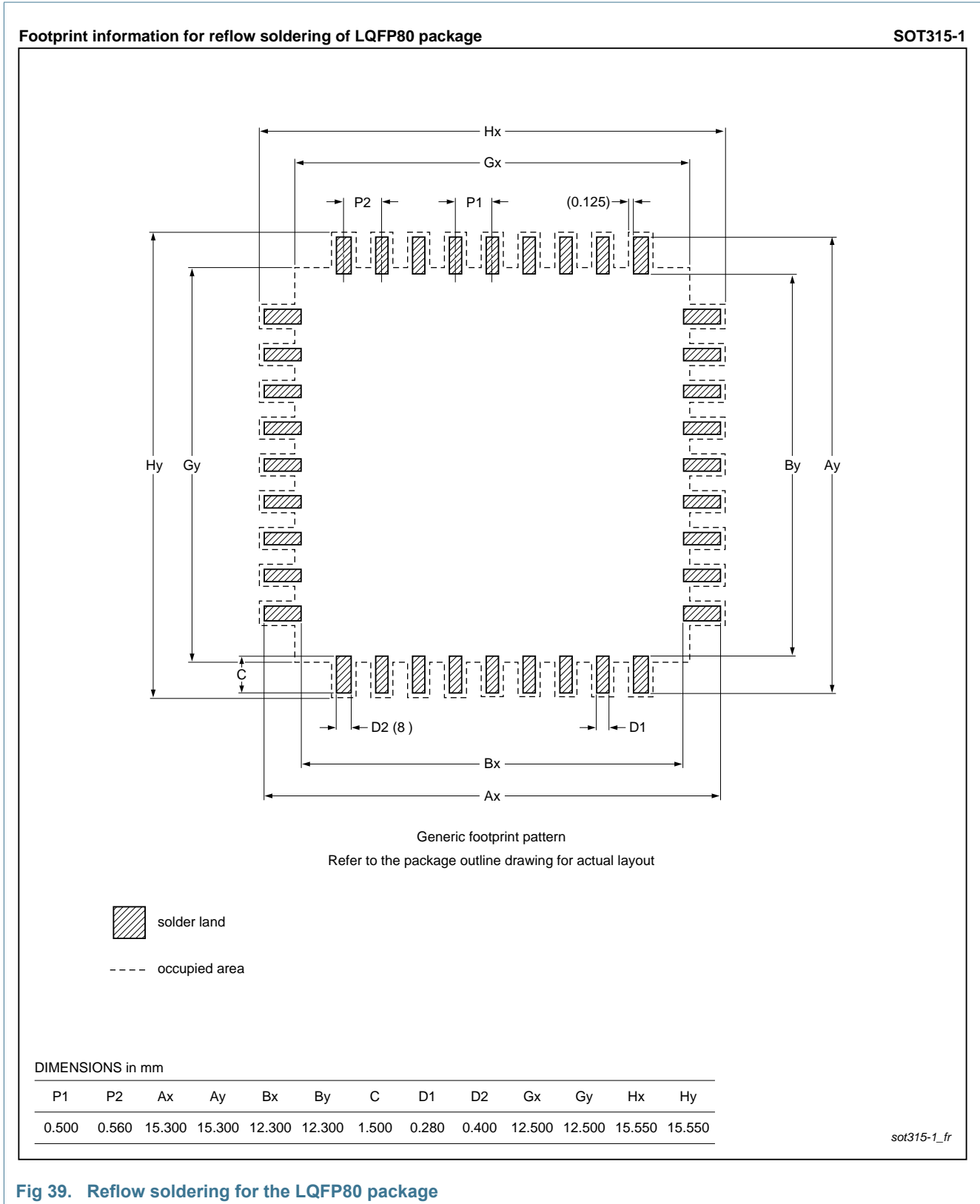


Fig 39. Reflow soldering for the LQFP80 package

18. Abbreviations

Table 25. Abbreviations

| Acronym | Description |
|---------|---|
| ADC | Analog-to-Digital Converter |
| AHB | Advanced High-performance Bus |
| AMBA | Advanced Microcontroller Bus Architecture |
| APB | Advanced Peripheral Bus |
| BOD | BrownOut Detection |
| CAN | Controller Area Network |
| DAC | Digital-to-Analog Converter |
| DMA | Direct Memory Access |
| EOP | End Of Packet |
| GPIO | General Purpose Input/Output |
| IRC | Internal RC |
| IrDA | Infrared Data Association |
| JTAG | Joint Test Action Group |
| MAC | Media Access Control |
| MIIM | Media Independent Interface Management |
| OTG | On-The-Go |
| PHY | Physical Layer |
| PLL | Phase-Locked Loop |
| PWM | Pulse Width Modulator |
| RMII | Reduced Media Independent Interface |
| SE0 | Single Ended Zero |
| SPI | Serial Peripheral Interface |
| SSI | Serial Synchronous Interface |
| SSP | Synchronous Serial Port |
| TTL | Transistor-Transistor Logic |
| UART | Universal Asynchronous Receiver/Transmitter |
| USB | Universal Serial Bus |

19. References

- [1] LPC176x/5x User manual UM10360:
http://www.nxp.com/documents/user_manual/UM10360.pdf
- [2] LPC175x Errata sheet:
http://www.nxp.com/documents/errata_sheet/ES_LPC175X.pdf
- [3] Technical note ADC design guidelines:
http://www.nxp.com/documents/technical_note/TN00009.pdf

20. Revision history

Table 26. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|------------------------------|---|--------------------|---------------|------------------------------|
| LPC1759_58_56_54_52_51 v.8.7 | 20200908 | Product data sheet | - | LPC1759_58_56_54_52_51 v.8.6 |
| Modifications: | <ul style="list-style-type: none"> Added Device revision C. | | | |
| LPC1759_58_56_54_52_51 v.8.6 | <td> | Product data sheet | - | LPC1759_58_56_54_52_51 v.8.5 |
| Modifications: | <ul style="list-style-type: none"> Updated max value of $t_{v(Q)}$ (data output valid time) in SPI mode to $3 \cdot T_{cy(PCLK)} + 2.5$ ns. See Table 15 “Dynamic characteristics: SSP pins in SPI mode”. Updated Section 2 “Features and benefits”: Added Boundary scan Description Language (BSDL) is not available for this device. Updated Figure 3 “LPC1759/58/56/54/52/51 memory map”: APB0 slot 7 (0x4001C000) was "reserved" and changed it to I2C0. Added a column for GPIO pins and device order part number to the ordering options table. See Table 2 “Ordering options”. | | | |
| LPC1759_58_56_54_52_51 v.8.5 | <td> | Product data sheet | - | LPC1759_58_56_54_52_51 v.8.4 |
| Modifications: | <ul style="list-style-type: none"> SSP timing diagram updated. SSP timing parameters $t_{v(Q)}$, $t_{h(Q)}$, t_{DS}, and t_{DH} added. See Section 12.7 “SSP interface”. SSP maximum bit rate in master mode corrected to 33 Mbit/s. Parameter $T_{j(max)}$ added in Table 5 “Limiting values”. Description of capture channels corrected in Section 8.21.1. | | | |
| LPC1759_58_56_54_52_51 v.8.4 | <td> | Product data sheet | - | LPC1759_58_56_54_52_51 v.8.3 |
| Modifications: | <ul style="list-style-type: none"> Table 4 “Pin description”: Changed RX_MCLK and TX_MCLK type from INPUT to OUTPUT. | | | |
| LPC1759_58_56_54_52_51 v.8.3 | 20140108 | Product data sheet | - | LPC1759_58_56_54_52_51 v.8.2 |
| Modifications: | <ul style="list-style-type: none"> Table 6 “Thermal resistance ($\pm 15\%$)”: Added $\pm 15\%$ to table title. | | | |
| LPC1759_58_56_54_52_51 v.8.2 | 20131018 | Product data sheet | - | LPC1759_58_56_54_52_51 v.8.1 |
| Modifications: | <ul style="list-style-type: none"> Table 5 “Limiting values”: Removed condition “5 V tolerant open-drain pins...” from V_I. Table 7 “Static characteristics”: <ul style="list-style-type: none"> Added Table note 3 “VDDA and VREFP should be tied to VDD(3V3) if the ADC and DAC are not used.” Added Table note 4 “VDDA for DAC specs are from 2.7 V to 3.6 V.” V_{DDA}/V_{REFP} spec changed from 2.7 V to 2.5 V. Table 18 “ADC characteristics (full resolution)”: <ul style="list-style-type: none"> Added Table note 1 “VDDA and VREFP should be tied to VDD(3V3) if the ADC and DAC are not used.” V_{DDA} changed from 2.7 V to 2.5 V. Table 19 “ADC characteristics (lower resolution)”: Added Table note 1 “VDDA and VREFP should be tied to VDD(3V3) if the ADC and DAC are not used.” | | | |

Table 26. Revision history ...continued

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|------------------------------|---|----------------------|---------------|----------------------------|
| LPC1759_58_56_54_52_51 v.8.1 | 20130912 | Product data sheet | - | LPC1759_58_56_54_52_51 v.8 |
| Modifications: | <ul style="list-style-type: none"> • Added Table 6 “Thermal resistance”. • Table 5 “Limiting values”: <ul style="list-style-type: none"> – Updated min/max values for $V_{DD(3V3)}$ and $V_{DD(REG)(3V3)}$. – Updated conditions for V_I. – Updated table notes. • Table 7 “Static characteristics”: Added Table note 14 “TCK/SWDCLK pin needs to be externally pulled LOW.” • Updated Section 15.1 “Suggested USB interface solutions”. • Added Section 5 “Marking”. • Changed title of Figure 29 from “USB interface on a self-powered device” to “USB interface with soft-connect”. | | | |
| LPC1759_58_56_54_52_51 v.8 | 20120809 | Product data sheet | - | LPC1759_58_56_54_52_51 v.7 |
| Modifications: | <ul style="list-style-type: none"> • Remove table note “The peak current is limited to 25 times the corresponding maximum current.” from Table 4 “Limiting values”. • Change $V_{DD(3V3)}$ to $V_{DD(REG)(3V3)}$ in Section 11.3 “Internal oscillators”. • Glitch filter constant changed to 10 ns in Table note 5 in Table 3. • Description of \overline{RESET} function updated in Table 3. • Pull-up value added for GPIO pins in Table 3. • Pin configuration diagram for LQFP80 package corrected (Figure 2). • Pin description of USB_UP_LED pin updated in Table 3. • R_{I1} and R_{I2} labels in Figure 26 updated. • Table note 9 updated in Table 3. • Table note 1 updated in Table 12. • Electromagnetic compatibility data added in Section 14.6. • Section 16 added. | | | |
| LPC1759_58_56_54_52_51 v.7 | 20110329 | Product data sheet | - | LPC1759_58_56_54_52_51 v.6 |
| Modifications: | <ul style="list-style-type: none"> • Pin description of pins P0[29] and P0[30] updated in Table note 4 of Table 3. Pins are not 5 V tolerant. • Typical value for Parameter N_{endu} added in Table 8. • Condition $3.0\text{ V} \leq V_{DD(3V3)} \leq 3.6\text{ V}$ added in Table 15. • Typical values for parameters $I_{DD(REG)(3V3)}$ and I_{BAT} with condition Deep power-down mode corrected in Table 6 and Table note 9, Table note 10, and Table note 11 updated. • For Deep power-down mode, Figure 8 updated and Figure 9 added. | | | |
| LPC1759_58_56_54_52_51 v.6 | 20100825 | Product data sheet | - | LPC1759_58_56_54_52_51 v.5 |
| Modifications: | <ul style="list-style-type: none"> • Section 7.30.2; BOD level corrected. • Added Section 10.2. | | | |
| LPC1759_58_56_54_52_51 v.5 | 20100716 | Product data sheet | - | LPC1759_58_56_54_52_51 v.4 |
| LPC1759_58_56_54_52_51 v.4 | 20100126 | Product data sheet | - | LPC1758_56_54_52_51 v.3 |
| LPC1758_56_54_52_51 v.3 | 20091119 | Product data sheet | - | LPC1758_56_54_52_51 v.2 |
| LPC1758_56_54_52_51 v.2 | 20090211 | Objective data sheet | - | LPC1758_56_54_52_51 v.1 |
| LPC1758_56_54_52_51 v.1 | 20090115 | Objective data sheet | - | - |

21. Legal information

21.1 Data sheet status

| Document status ^{[1][2]} | Product status ^[3] | Definition |
|-----------------------------------|-------------------------------|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification | This document contains data from the preliminary specification. |
| Product [short] data sheet | Production | This document contains the product specification. |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

21.2 Definitions

Draft — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

Short data sheet — A short data sheet is an extract from a full data sheet with the same product type number(s) and title. A short data sheet is intended for quick reference only and should not be relied upon to contain detailed and full information. For detailed and full information see the relevant full data sheet, which is available on request via the local NXP Semiconductors sales office. In case of any inconsistency or conflict with the short data sheet, the full data sheet shall prevail.

Product specification — The information and data provided in a Product data sheet shall define the specification of the product as agreed between NXP Semiconductors and its customer, unless NXP Semiconductors and customer have explicitly agreed otherwise in writing. In no event however, shall an agreement be valid in which the NXP Semiconductors product is deemed to offer functions and qualities beyond those described in the Product data sheet.

21.3 Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the *Terms and conditions of commercial sale* of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Non-automotive qualified products — Unless this data sheet expressly states that this specific NXP Semiconductors product is automotive qualified, the product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. NXP Semiconductors accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

In the event that customer uses the product for design-in and use in automotive applications to automotive specifications and standards, customer (a) shall use the product without NXP Semiconductors' warranty of the product for such automotive applications, use and specifications, and (b)

whenever customer uses the product for automotive applications beyond NXP Semiconductors' specifications such use shall be solely at customer's own risk, and (c) customer fully indemnifies NXP Semiconductors for any liability, damages or failed product claims resulting from customer design and use of the product for automotive applications beyond NXP Semiconductors' standard warranty and NXP Semiconductors' product specifications.

21.4 Trademarks

Notice: All referenced brands, product names, service names and trademarks are the property of their respective owners.

I²C-bus — logo is a trademark of NXP B.V.

22. Contact information

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

23. Contents

| | | | | | |
|----------|---|-----------|-----------|--|-----------|
| 1 | General description | 1 | 8.18.1 | Features | 24 |
| 2 | Features and benefits | 1 | 8.19 | I ² C-bus serial I/O controllers | 24 |
| 3 | Applications | 3 | 8.19.1 | Features | 24 |
| 4 | Ordering information | 4 | 8.20 | I ² S-bus serial I/O controllers (LPC1759/58/56 only) | 24 |
| 4.1 | Ordering options | 4 | 8.20.1 | Features | 25 |
| 5 | Marking | 5 | 8.21 | General purpose 32-bit timers/external event counters | 25 |
| 6 | Block diagram | 6 | 8.21.1 | Features | 25 |
| 7 | Pinning information | 7 | 8.22 | Pulse width modulator | 26 |
| 7.1 | Pinning | 7 | 8.22.1 | Features | 26 |
| 7.2 | Pin description | 7 | 8.23 | Motor control PWM | 27 |
| 8 | Functional description | 14 | 8.24 | Quadrature Encoder Interface (QEI) | 27 |
| 8.1 | Architectural overview | 14 | 8.24.1 | Features | 27 |
| 8.2 | ARM Cortex-M3 processor | 14 | 8.25 | Repetitive Interrupt (RI) timer | 28 |
| 8.3 | On-chip flash program memory | 14 | 8.25.1 | Features | 28 |
| 8.4 | On-chip SRAM | 14 | 8.26 | ARM Cortex-M3 system tick timer | 28 |
| 8.5 | Memory Protection Unit (MPU) | 15 | 8.27 | Watchdog timer | 28 |
| 8.6 | Memory map | 15 | 8.27.1 | Features | 28 |
| 8.7 | Nested Vectored Interrupt Controller (NVIC) | 17 | 8.28 | RTC and backup registers | 29 |
| 8.7.1 | Features | 17 | 8.28.1 | Features | 29 |
| 8.7.2 | Interrupt sources | 17 | 8.29 | Clocking and power control | 29 |
| 8.8 | Pin connect block | 17 | 8.29.1 | Crystal oscillators | 29 |
| 8.9 | General purpose DMA controller | 17 | 8.29.1.1 | Internal RC oscillator | 30 |
| 8.9.1 | Features | 18 | 8.29.1.2 | Main oscillator | 30 |
| 8.10 | Fast general purpose parallel I/O | 18 | 8.29.1.3 | RTC oscillator | 30 |
| 8.10.1 | Features | 19 | 8.29.2 | Main PLL (PLL0) | 31 |
| 8.11 | Ethernet (LPC1758 only) | 19 | 8.29.3 | USB PLL (PLL1) | 31 |
| 8.11.1 | Features | 19 | 8.29.4 | Wake-up timer | 31 |
| 8.12 | USB interface | 20 | 8.29.5 | Power control | 32 |
| 8.12.1 | USB device controller | 20 | 8.29.5.1 | Sleep mode | 32 |
| 8.12.1.1 | Features | 20 | 8.29.5.2 | Deep-sleep mode | 32 |
| 8.12.2 | USB host controller (LPC1759/58/56/54 only) | 21 | 8.29.5.3 | Power-down mode | 33 |
| 8.12.2.1 | Features | 21 | 8.29.5.4 | Deep power-down mode | 33 |
| 8.12.3 | USB OTG controller (LPC1759/58/56/54 only) | 21 | 8.29.5.5 | Wakeup interrupt controller | 33 |
| 8.12.3.1 | Features | 21 | 8.29.6 | Peripheral power control | 33 |
| 8.13 | CAN controller and acceptance filters | 21 | 8.29.7 | Power domains | 33 |
| 8.13.1 | Features | 22 | 8.30 | System control | 35 |
| 8.14 | 12-bit ADC | 22 | 8.30.1 | Reset | 35 |
| 8.14.1 | Features | 22 | 8.30.2 | Brownout detection | 36 |
| 8.15 | 10-bit DAC (LPC1759/58/56/54 only) | 22 | 8.30.3 | Code security (Code Read Protection - CRP) | 36 |
| 8.15.1 | Features | 22 | 8.30.4 | APB interface | 36 |
| 8.16 | UARTs | 23 | 8.30.5 | AHB multilayer matrix | 37 |
| 8.16.1 | Features | 23 | 8.30.6 | External interrupt inputs | 37 |
| 8.17 | SPI serial I/O controller | 23 | 8.30.7 | Memory mapping control | 37 |
| 8.17.1 | Features | 23 | 8.31 | Emulation and debugging | 37 |
| 8.18 | SSP serial I/O controller | 23 | 9 | Limiting values | 38 |
| | | | 10 | Thermal characteristics | 39 |

continued >>

| | | |
|-----------|---|-----------|
| 10.1 | Thermal characteristics | 39 |
| 11 | Static characteristics | 40 |
| 11.1 | Power consumption | 43 |
| 11.2 | Peripheral power consumption | 46 |
| 11.3 | Electrical pin characteristics | 47 |
| 12 | Dynamic characteristics | 49 |
| 12.1 | Flash memory | 49 |
| 12.2 | External clock | 49 |
| 12.3 | Internal oscillators | 50 |
| 12.4 | I/O pins | 50 |
| 12.5 | I ² C-bus | 51 |
| 12.6 | I ² S-bus interface (LPC1759/58/56 only) | 53 |
| 12.7 | SSP interface | 55 |
| 12.8 | USB interface | 57 |
| 12.9 | SPI | 58 |
| 13 | ADC electrical characteristics | 60 |
| 14 | DAC electrical characteristics (LPC1759/58/56/54 only) | 63 |
| 15 | Application information | 64 |
| 15.1 | Suggested USB interface solutions | 64 |
| 15.2 | Crystal oscillator XTAL input and component selection | 67 |
| 15.3 | XTAL Printed-Circuit Board (PCB) layout guidelines | 68 |
| 15.4 | Standard I/O pin configuration | 69 |
| 15.5 | Reset pin configuration | 70 |
| 15.6 | ElectroMagnetic Compatibility (EMC) | 71 |
| 16 | Package outline | 72 |
| 17 | Soldering | 73 |
| 18 | Abbreviations | 74 |
| 19 | References | 74 |
| 20 | Revision history | 75 |
| 21 | Legal information | 77 |
| 21.1 | Data sheet status | 77 |
| 21.2 | Definitions | 77 |
| 21.3 | Disclaimers | 77 |
| 21.4 | Trademarks | 78 |
| 22 | Contact information | 78 |
| 23 | Contents | 79 |

Please be aware that important notices concerning this document and the product(s) described herein, have been included in section 'Legal information'.

© NXP Semiconductors N.V. 2020.

All rights reserved.

For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

Date of release: 8 September 2020

Document identifier: LPC1759_58_56_54_52_51

Looking for pricing, stock, or lifecycle information?

Click below to explore more details on WIN SOURCE:

- ⊖ [View LPC1751FBD80,551 on WIN SOURCE](#)
- ⊖ [NXP / Nexperia Information](#)

Optimize Your Supply Chain with WIN SOURCE Solutions

- ✓ Global Sourcing Solution
- ✓ Obsolete Management
- ✓ Cost Control Management
- ✓ Shortage Management
- ✓ Alternative Solution
- ✓ Excess Inventory Management